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WATERTOWN ARSENAL LABORATORIES

MS-19

Monograph Series

URANIUM ALLOYS FOR CRITICAL ORDNANCE COMPONENTS

97-p

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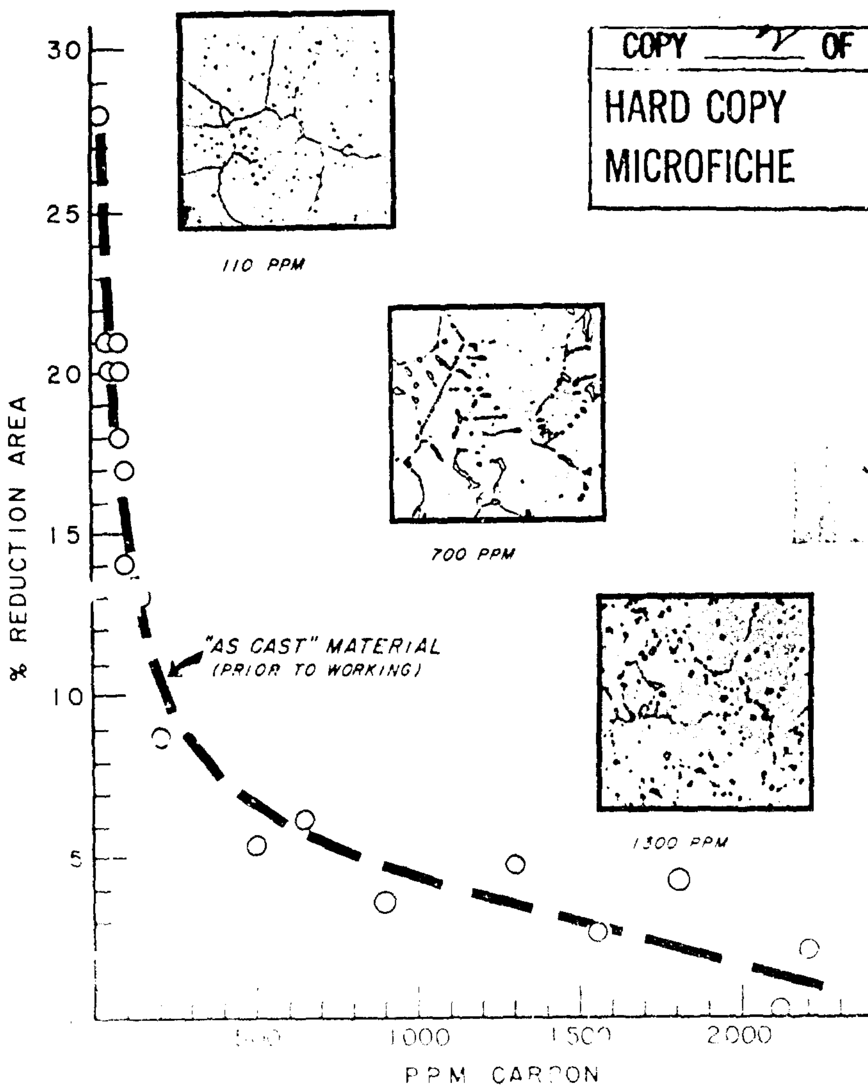

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SPECIFICATION COORDINATION MEETING

ON

URANIUM MATERIALS FOR DAVY CROCKETT AND OTHER ORDNANCE PROGRAMS

HELD AT

WATERTOWN ARSENAL, WATERTOWN, MASS.

7 JUNE 1960

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WATERTOWN ARSENAL
WATERTOWN, MASS.

SPECIFICATION COORDINATION MEETING

URANIUM MATERIALS FOR DAVY CROCKETT AND OTHER ORDNANCE PROGRAMS

Agenda
7 June 1960

Fifth Floor Conference Room
Building No. 39 - Room 521

Watertown Arsenal
Watertown, Mass.

Time	Subject
1000 - 1005	Welcome
	Colonel R. B. Braid, Commanding Officer, Watertown Arsenal
	Introduction and Background
1005 - 1020	Mr. F. J. Rizzitano, Meeting Chairman - Watertown Arsenal Laboratories - Ordnance interest in uranium alloys in armor and ammunition applications. Unclassified depleted uranium supplied to Ordnance Corps under AEC-DOD agreement. S.S. materials accountability required by AEC. Health physics requirements for uranium processing and in ballistic firings.
1020 - 1030	Mr. L. Horowitz, Deputy Director for Davy Crockett, Picatinny Arsenal Mr. M. Bornstein, Staff Assistant for Industrial Transition, Davy Crockett, Picatinny Arsenal - Developmental structural ammunition components requiring high-strength (140,000 - 175,000 psi yield strength) hollow extrusions. Application requires ductility and toughness at -40°F together with good resistance to normal atmospheric corrosion. Limited quantities required in developmental program as well as over-all requirement will be outlined.
1030 - 1045	Mr. J. Piskorski, Project Coordinator for Industrial Engineering Division, Lake City Arsenal - Immediate Ordnance requirements for moderate-strength uranium alloys for ex-caliber spotting rounds. Quantities, wrought shapes, dimensions and tolerances. Future considerations for use of cast products. Machining, assembly and storage for Davy Crockett ex-caliber spotting round will be briefly discussed.

Agenda (Cont)

7 June 1960

Time	Subject
	Technical Discussions
1045 - 1130	Alloy Development - Mr. J. A. Misencik, Watertown Arsenal Laboratories - Recent development and evaluation of the alloys of uranium; melting, casting, heat treating studies, mechanical properties of various alloys as well as metallographic techniques will also be discussed.
1130 - 1215	Tour of Watertown Arsenal Laboratories Facilities
	Mechanical Services Branch - Mr. S. E. Siemen and Mr. N. Rosato - Machine facilities demonstrating trepanning, contour machining, test specimen machining and special purpose machines for uranium, titanium and high-strength steel. Exhibit of titanium shapes.
	Experimental Melt Laboratory - Mr. D Corbett and Mr. M. McCormick - Melting equipment such as vacuum induction, consumable and non-consumable vacuum arc, cold mold arc button furnaces for melting and casting uranium and other alloys and highly reactive metals and zone refining unit will be viewed or demonstrated.
	Group A - Tour of Mechanical Services Branch, followed by Experimental Melt Laboratory
	Group B - Tour of Experimental Melt Laboratory, followed by Mechanical Services Branch
1215 - 1315	Lunch - Watertown Arsenal Cafeteria
1330 - 1345	Metallurgical Processing - Mr. E. N. Kinas, Watertown Arsenal Laboratories - Forging, extruding (forward and backward), rolling, swaging, straightening, etc., will be discussed.
1345 - 1400	Surface Characteristics - Mr. M. M. Jacobson, Watertown Arsenal Laboratories - Problems relating to corrosion characteristics, pyrophoric properties and chemical analysis will be discussed.
1400 - 1445	Specification - Mr. J. F. Coulter, Watertown Arsenal Laboratories - Discussion of MIL-U- 46045(Ord), Uranium Alloys, Wrought, Bars, Billets and Tubular Shapes. Technical discussion of the requirements set out in the specification.
1445 - 1500	Summary and Adjournment - Mr. F. J. Rizzitano, Watertown Arsenal Laboratories

WATERTOWN ARSENAL
WATERTOWN, MASS.

SPECIFICATION COORDINATION MEETING

URANIUM MATERIALS FOR DAVY CROCKETT AND OTHER ORDNANCE PROGRAMS

Attendance List
7 June 1960

INDUSTRIAL REPRESENTATIVES:

Mr. L. Abrams, W. R. Grace Company

Mr. R. Bish, Westinghouse Corporation

Mr. F. Burke, Metals and Controls, Inc.

Mr. P. Corzine, Nuclear Metals, Inc.

Mr. D. Craig, Dow Chemical Company

Mr. J. Durant, Englehart Industries (Makepeace Div.)

Mr. J. Farr, National Lead Company

Mr. J. Fitzpatrick, Nuclear Metals, Inc.

Mr. N. Gardner, Nuclear Metals, Inc.

Mr. J. Huss, National Lead Company

Mr. A. Kondrat, Westinghouse Corporation

Mr. G. Ladd, Sylvania Corning Company

Mr. T. Niemeyer, Dow Chemical Company

Mr. A. Schuetz, Bridgeport Brass Company

Mr. J. Staricenka, Metals and Controls, Inc.

Mr. A. Stewart, Jr., National Lead Company

Mr. C. Whitman, Sylvania Corning Company

Attendance List (Cont)
7 June 1960

ORDNANCE CORPS PERSONNEL:

Ordnance Weapons Command
- Mr. F. Wittber

Picatinny Arsenal
- Mr. M. Bornstein

Lake City Arsenal
- Mr. O. Brown
- Mr. E. Myers
- Mr. J. Piskorski
- Mr. A. Travostino (Remington Arms Co.)

Frankford Arsenal
- Mr. R. Edelman

Ordnance Ammunition Command
- Mr. E. Bailey
- Mr. A. Halleck

Ordnance Materials Research Office
- Mr. I. Berman
- Mr. T. Dunn
- Dr. L. Foster
- Mr. W. Hawley
- Mr. A. Jones
- Mr. N. Reed

Watertown Arsenal
- Colonel R. B. Braid, Commanding Officer
- Lt Col W. A. Eadie, Jr.
- Lt Col R. R. Fisk
- Mr. F. Brown
- Mr. G. Chandley
- Mr. J. Downing
- Mr. D. Fleck
- Mr. F. George
- Mr. J. Hanley
- Mr. J. Murphy
- Mr. B. Polonsky
- Mr. E. Shebek

Watertown Arsenal Laboratories
- Mr. K. N. Hegge, Deputy Director
- Mr. F. J. Rizzitano, Chairman
- Mr. J. Armour
- Mr. D. Corbett
- Mr. J. Coulter
- Mr. M. Jacobson
- Mr. E. Kinas
- Mr. M. Levy
- Mr. M. McCormick
- Mr. J. Misencik
- Mr. K. Murray
- Mr. N. Rosato
- Mr. S. Vigo

ORDNANCE CORPS
WATERTOWN ARSENAL
WATERTOWN 72, MASSACHUSETTS

7 June 1960

REPRESENTATIVES OF URANIUM INDUSTRY AND ORDNANCE CORPS PERSONNEL:

Traditionally, Ordnance Corps materials development has been directed toward constructional materials, e.g., steel, titanium, aluminum, plastics, etc., and which in the last few years has been greatly accelerated in order to obtain lighter weight Ordnance weapons. Concurrently, parallel requirements have arisen for high-density engineering materials. The new Ordnance components for which high-density materials are being considered all require strength with associated ductility and toughness, resistance to normal atmospheric corrosion, and suitable workability and fabricability for manufacturing system components. The high-density applications vary however from those requiring sufficient mass to enable matching of ballistic trajectories (spotting rounds) to those requiring combined resistance to ballistic penetration and gamma shielding (armor).

Materials requirements in Ordnance Corps specifications are usually defined by means of mechanical and physical properties, and the actual alloy composition is left to the discretion of the materials producer. Insofar as this is possible, this practice is being followed in the proposed military specification for wrought uranium alloys being discussed here today. Our limited metallurgical studies to date have indicated that carbon content must be restricted to a maximum of 150 parts per million to obtain ductile, tough uranium alloys. The required resistance to corrosion in normal atmospheres demands at least 8% molybdenum with and without addition alloying elements. Therefore our basic structural alloys today are U-8%Mo and U-8%Mo-1%Ti to obtain ductile, tough, and corrosion-resistant high-density alloys.

The preparation of a military specification for uranium, of course, indicates that the Ordnance Corps plans to procure high-strength, wrought uranium alloy products. Our immediate industrial requirements are for small diameter bar stock (approximately one inch) suitable for subsequent machining in automatic screw machines. Ordnance developmental activities require small quantities of uranium alloys in bar, hollow extrusions, and plate forms. Cast products are also being considered for some applications. These, however, are not being discussed here today.

It is hoped that this meeting will be of mutual benefit to both the Industrial and Ordnance Corps representatives here today. We wish at this time to express our gratitude for your interest and assistance in the development of this first Ordnance Corps specification for uranium alloys.

R. B. BRAID
Colonel, Ord Corps
Commanding

AMMUNITION REQUIREMENTS

by

M. Bornstein

There shall be presented some of the primary considerations for selecting depleted uranium as the basic material for the XM101 20MM spotting cartridge and a brief review of:

a. The background for selecting this material.

b. The development time scales permitted by the Davy Crockett program.

Picatinny Arsenal, as the research and development systems manager for the Davy Crockett system has, during the past two years, aggressively pursued the development of a 20MM spotting cartridge for use in conjunction with the major caliber round. Frankford Arsenal and the Diamond Ordnance Fuze Laboratories were assigned the basic development program by Picatinny Arsenal, and a member of Lake City Arsenal will discuss the materials requirements in greater detail later in the program.

In order to achieve the desired range and accuracy in the 20MM spotting cartridge and to achieve a ballistic co-efficient of approximately 1, a highly dense material was required for the 20MM shell body. The material selected during the initial research and development phases was Mallory-1000, basically a tungsten alloy. This material, while meeting the military requirements for the spotting projectile, was considered exceedingly costly, and difficult to machine. A study was conducted by Watertown Arsenal during the Second and Third Quarters of Fiscal Year 1959 which indicated that depleted uranium with approximately 8% molybdenum could be used as a promising alternative material for the Mallory-1000 previously approved by the Research and Development System Manager.

A brief comparison of the two materials indicates the following:

	Mallory-1000	Depleted Uranium Alloy
a. Density	16.5 to 17 gm/cc	18.5 - 19.9 gm/cc
b. Cost	$10.00 lb.	$4.50 lb.

While the density of uranium is slightly greater than Mallory metal, (approximately 200 grains more per projectile) the cost of the depleted uranium is 50% lower than Mallory material.

Ballistic tests conducted during March of 1960 indicated that the uranium projectile behaved satisfactorily under interior and exterior ballistic conditions.

For those who are not familiar with the physical characteristics, the XM101 20MM projectile will be described briefly at this time (Figure 1). The projectile consists of the following:

a. A cartridge case (steel or aluminum)

b. Projectile body (uranium)

c. Fuze (point detonating)

d. A plastic rotating band which is assembled to the body to prevent "blowby" of the propelling gases.

To emphasize further the necessity for the availability of uranium processing and fabricating facilities there has been prepared a chart outlining the time scales available to the research and development agency for the development, testing and industrial engineering of the XM101 20MM spotting projectile (Figure 2).

It will be noted that the engineering design phase was initiated during the Fourth Quarter of 1958 and has been progressing for approximately two years. The final engineering test phase was initiated in the Second Quarter of 1960 and is due to be completed during the Second Quarter of 1961, a period of slightly over eight months. It will be noted further that the industrial engineering program, which was initiated during the Second Quarter of Fiscal Year 1959, will likewise be completed in the Second Quarter of Fiscal Year 1961.

Due to the exceedingly telescoped nature of the Davy Crockett program, it becomes necessary to initiate the production of war reserve quantities of spotting ammunition during October, 1960 or the Second Quarter of Fiscal Year 1961.

A brief summary of the material requirements for the next five years, which is of prime interest is as follows:

Fiscal Year	Material Requirements in lbs.
FY61	39,000
FY62	93,000
FY63	36,000
FY64	31,000
FY65	33,000
	Total - 232,000 lbs.

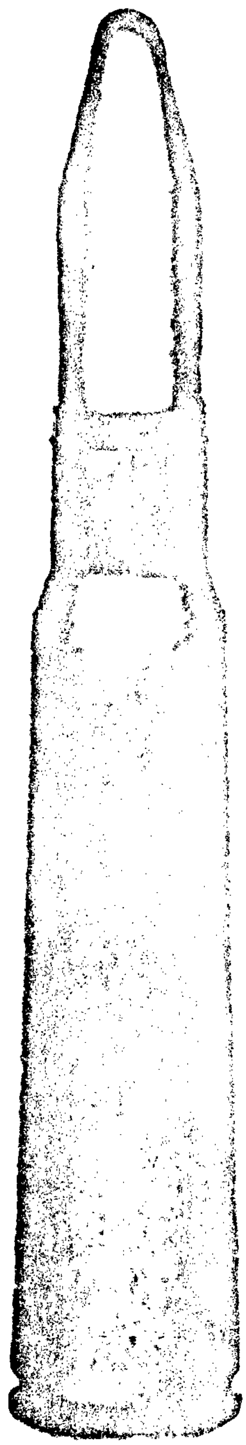
In addition, a quantity of uranium will also be required for a special round and these quantities are as follows:

Year	Material Requirements in Lbs.
FY63 (starting July, 1962)	7,875

The afore-mentioned limited time scales make it apparent that sources for the processing of depleted uranium and fabrication of this material must of necessity be fully operational no later than the Second Quarter of 1961 (October 1960) if the Ordnance Corps is to meet its commitments to the user, the Continental Army Command.

In conclusion, it is well to re-emphasize the importance and necessity for the continued support and cooperation of industrial organizations in developing the facilities and production "know-how" for providing the Ordnance Corps with depleted uranium alloy to support the Davy Crockett program.

7 June 1960
PICATINNY ARSENAL



Cartridge, Spotting, 20 mm XM101 or XM106 (F.A. 2 piece case)

FIGURE 1

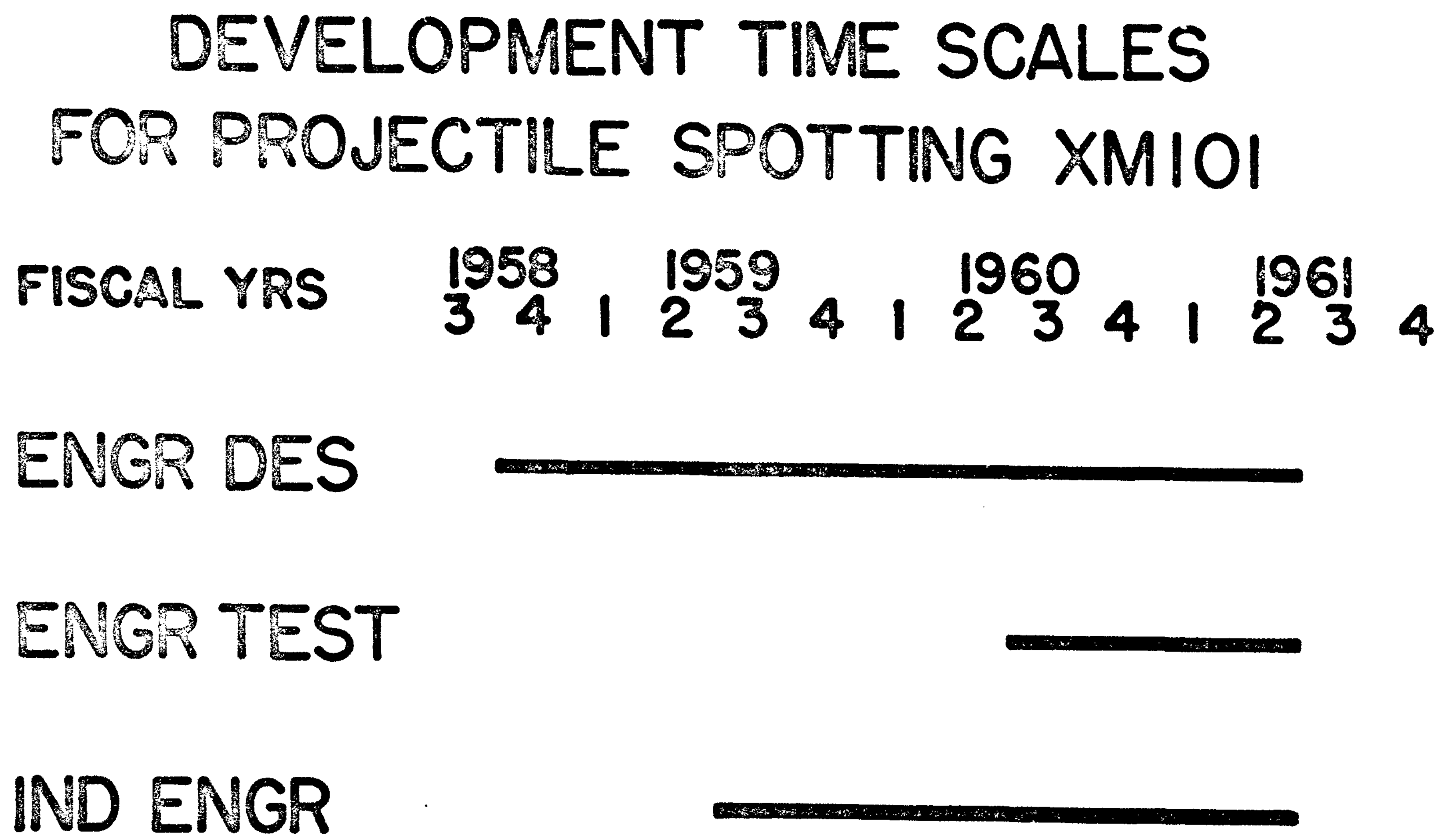

DEVELOPMENT TIME SCALES
FOR PROJECTILE SPOTTING XM101
FISCAL YRS
1958 1959 1960 1961
3 4 1 2 3 4 1 2 3 4 1 2 3 4
ENGR DES
ENGR TEST
IND ENGR

FIGURE 2

URANIUM ALLOY BAR FOR XM101 PROJECTILE

by

J. Piskorski

About one year ago the Industrial Engineering Division at Lake City Arsenal was introduced to the Davy Crockett program and assigned the responsibility for industrial engineering of that segment of the program having to do with XM101 20MM ex-caliber spotting cartridge. Because of the desired military characteristics and ballistics, many unique design considerations were required. Among these was the necessity for an extremely heavy projectile within the tight dimensional limits required of the heavy metals for the basic material of the shell body. During development of this item by research and development personnel at Frankford Arsenal, initial investigation considered an alloy of 90% tungsten, 6% nickel, 4% copper, which resulted in a material possessing a specific gravity of 17. This material was thoroughly investigated and tested and proved to be adequate insofar as physical properties and ballistic performance were concerned. There were some objections from a production machining standpoint. These were not considered overly serious and, all in all, the shell body could very well have been manufactured of this tungsten alloy had the costs of the raw slugs been more within reason.

Research and development investigations at Watertown Arsenal established that equivalent or better shell bodies could be manufactured of a depleted uranium alloy at a much less cost per cartridge. Thus, after numerous tests and discussions a uranium alloy, in accordance with the recommendation of Watertown Arsenal, was adopted as the shell body material and the process to manufacture these in quantity evolved about this material. This, of course, involved such problems as accountability, health physics, scrap handling, etc., but they have all been resolved, and Lake City Arsenal is currently tooling up to cut bar stock. Bar stock will be provided by Watertown Arsenal to requirements for automatic screw machine operation. Watertown Arsenal, it may be presumed, purchases the uranium alloy from a commercial source in accordance with requirements of the proposed military specification to be discussed later. Basically, our requirements called for a bar 12-feet long and sufficiently straight to pass freely through a 31/32" I.D. tube. The bar diameter specified should be .844" - .006" and any ellipticity must be within diameter tolerance.

Minimum physical properties* should be: Yield Strength - 90,000 psi, Ultimate Tensile Strength - 100,000 psi, Elongation - 2%, Reduction of Area - 4%, V-Notch Charpy at -40°F - 2 ft-lbs. There is listed in Table I an approximation of the amount of uranium alloy bar which will be required for delivery to Lake City Arsenal for the next five fiscal years. The schedules have fluctuated in the past and may very likely do so in the future; therefore, these figures represent what is currently in the plans.

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*Chairman's footnote: Minimum in this case referring to the lowest mechanical properties of sintered tungsten alloys that withstood a ballistic firing.

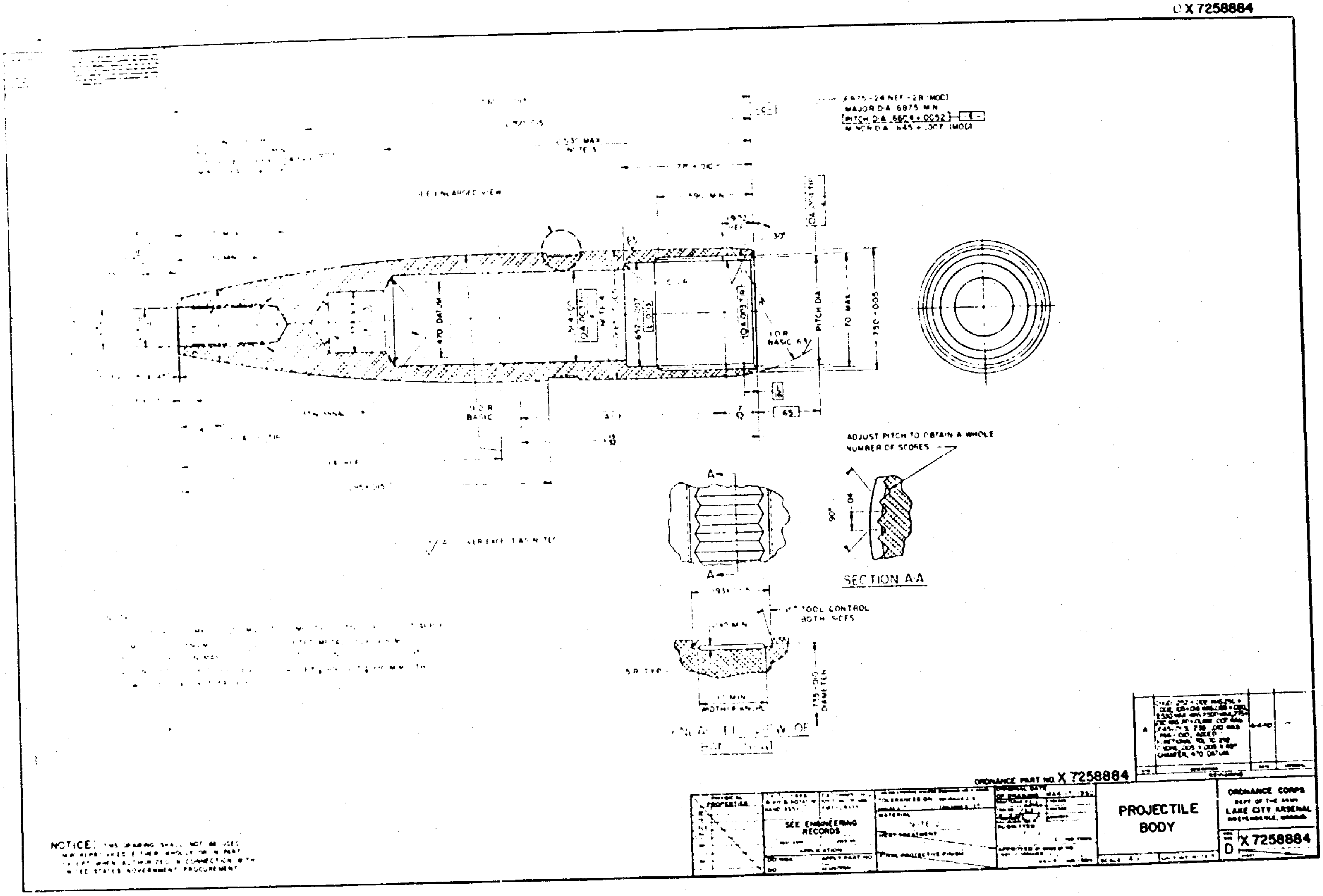
TABLE I

URANIUM ALLOY BAR REQUIRED FOR SCHEDULE

Schedule	12' Bars Req'd	Approx. Lin. Ft.	Approx. Wt. at 53 lbs/bar
July 1960	30	360	1,590
August 1960	66	792	3,500
September 1960	32	384	1,700
October 1960	54	648	2,860
November 1960	135	1,620	7,155
December 1960	223	2,676	11,820
January 1961	210	2,520	11,130
February 1961	210	2,520	11,130
March 1961	210	2,520	11,130
April 1961	156	1,872	8,270
Total FY61	1,326	15,912	70,285
Total FY62	2,124	25,488	112,572
Total FY63	819	9,828	43,407
Total FY64	701	8,412	37,153
Total FY65	767	9,204	40,651
5-Year Total	5,737	68,844	304,068

For this current plan all of this uranium bar is to be delivered to Lake City Arsenal since this Arsenal will manufacture, assemble, load and pack all of the components of the XM101 cartridge except the fuze. A machined projectile is shown in the attached figure.

7 June 1960
LAKE CITY ARSENAL


D X 7258884
.6875-24 NEF-2B (MOD)
MAJOR DIA .6875 MIN
PITCH DIA .6604+.0052
MINOR DIA .645+.007 (MOD)
SEE ENLARGED VIEW
.470 DATUM
PITCH DIA
70 MAX
.750-.005
ADJUST PITCH TO OBTAIN A WHOLE NUMBER OF SCORES
SECTION A-A
TOOL CONTROL BOTH SIDES
NOTICE:
ORDNANCE PART NO. X 7258884
SEE ENGINEERING RECORDS
PROJECTILE BODY
ORDNANCE CORPS
LAKE CITY ARSENAL
D X 7258884

URANIUM ALLOYS FOR ORDNANCE COMPONENTS

by

J. A. Misencik

Introduction

During the past several years the Ordnance Corps has generated a requirement for a structural engineering material that possesses high strength, high density, and a reasonable amount of ductility and toughness for use in the production of critical Ordnance components. Under the sponsorship of Picatinny Arsenal, wrought uranium alloys (unclassified, depleted) have been developed at Watertown Arsenal to meet this requirement. The following gives the history and fabrication of the uranium melting stock to be supplied contractors. Also discussed is the Ordnance Corps alloy-development program, including alloy development, preliminary extrusion, heat treatment, and metallographic techniques.

Preparation of Melting Stock

The depleted unclassified uranium used in Army Ordnance is obtained from the Atomic Energy Commission on joint programs.

The uranium salt that is used to produce the uranium metal is UF_4 (uranium tetrafluoride) which has been reduced from UF_6 (uranium hexafluoride). This preliminary reduction operation is conducted at the Atomic Energy Commission installation at Paducah, Kentucky. The uranium tetrafluoride (UF_4) is the high-purity green salt. This is then shipped to the Mallinckrodt Chemical Corp., St. Louis, Missouri, for bomb reduction of the green salt with magnesium to give a uranium "dingot" and a slag of magnesium fluoride. The name "dingot" is used rather than "ingot" to indicate that the uranium resulted from a direct reduction from the salt to uranium metal. The resultant dingot and slag are separated and the dingot is machined (scalped) to remove any slag and refractory that may adhere to the surface. The dingot weighs approximately 1800 lbs. and is the yield from 3000 lbs. of charged green salt.

Chemical analysis of the resultant dingot material as supplied by the Atomic Energy Commission is approximately as follows:

C	< 100 ppm	Ca	20 ppm
Fe	15 ppm	Mn	2 ppm
Ni	30 ppm	Co	4 ppm
Cr	2 ppm	Cu	15 ppm
V	20 ppm	Mg	2 ppm
Si	30 ppm	Li	0.2 ppm
Al	10 ppm	Be	0.2 ppm
H	< 1 ppm	B	0.4 ppm
N	10 ppm	O	20 ppm

Note that the amounts of all elements fall below that specified in the specification. Further processing of the dingot is dependent upon the melting and alloying facilities available. The dingot may be extruded and rolled to give 1-1/2" diameter bar stock suitable for melting or the entire dingot may be re-melted and alloyed.

The dingot or melting stock that will be furnished to industrial processing facilities to meet the uranium military specification requirements will be supplied as described above.

Co-Reduction Process

Attempts have been made to eliminate the alloying step by co-reduction of the UF_4 with molybdenum in the bomb reduction process. Several dingots have been reduced using this technique; however, the last dingot contained extensive porosity.

Rolling tests conducted with co-reduced stock were not successful. The billet cracked extensively during the rolling operation.

Extrusion to bar stock using co-reduced stock has been successful.

Use of co-reduction process to produce melting stock that will be supplied to the contractors is not planned at this time.

Ordnance Corps Alloy Development

Melting and Alloying - During the alloy development program at Watertown Arsenal, 1-1/2" diameter bar stock is used as melting stock. Small laboratory size ingots each weighing 30-40 lbs. are melted of binary, ternary, and quaternary alloys of uranium. The alloying elements studied included varying amounts of columbium, zirconium, molybdenum, tantalum, and vanadium. Extensive use is made of published phase diagrams in the binary systems to determine melting points, solid solubility limits, presence of inter-metallic compounds and low melting eutectics; however, little or no data is to be found concerning the ternary or quaternary systems.

The melting is accomplished in a vacuum-induction furnace which can be evacuated to at least .8 micron. The induction heating of uranium does not necessarily promote good mixing, and to minimize segregation which can be a problem when melting materials of extensive density difference such as uranium and titanium, the melt is super-heated 100 - 200°F above the melting point. In the laboratory heats, the melt is contained in a stabilized zirconia crucible during melting and is lip poured into a graphite mold. In order to minimize carbon pickup, the mold is washed with zirconia

mixed with water and water glass. It was determined early in the program that carbon in excess of 150 parts per million is detrimental to the ductility of the resultant material and is to be avoided. Low-carbon melt stock is used in all-alloy studies and will be used by the contractor to produce the required shapes (See Table I).

The as-cast metallurgical and mechanical properties are determined from the ingot, and the remaining part of the ingot is further processed to obtain as-extruded properties and heat-treatment stock.

Extrusion

Extrusion of the alloy study ingots is accomplished by heating the ingots to 1650°F for approximately 2-1/2 hours in an evacuated copper container. Billet is extruded from 2.8" dia. to approximately .75" dia. The copper cladding serves four purposes:

1. Permits the heating of billets to be carried out in an ordinary furnace and still protect the surface of the uranium.

2. Separates the uranium from the steel die, thus preventing the formation of a low temperature eutectic between the uranium and the iron in the die.

3. Serves as a lubricant during extrusion.

4. Acts as an insulator to maintain uranium surface temperatures high enough to prevent surface tears.

The copper forms a thin protective coating over the extruded bar stock. The as-extruded properties were obtained.

Heat-Treatment Studies

Blanks cut from the extruded bar stock are used in the heat-treatment studies. These heat-treatment studies have resulted in obtaining a wide variation in properties on one alloy. The properties of L93 are presented in Table II.

Limited heat-treatment studies of U-8%Mo and U-8%Mo-1%Ti have shown that heat treatment will not appreciably increase the mechanical properties above those presented in Tables III and IV since this alloy is single phase.

To date, 134 ingots of 70 different alloys have been melted at Watertown Arsenal; 38 of these remain to be tested in the as-extruded condition and heat treated.

This program has led to the development of at least two uranium alloys which have properties which make them usable engineering materials. There may be others developed before completion of the program. The two alloys are: U-8%Mo and U-8%Mo-1%Ti. These alloys are currently being used in the prototype manufacture of components in the research and development stage and also were used, evaluated, and tested for the XM101 spotting round.

Many alloys have been developed which will meet the mechanical properties as required in the specification at the different strength levels; however, the corrosion resistance of all but the U-8%Mo and the U-8%Mo-1%Ti will not meet the specification requirement. Further studies are in progress to overcome this deficiency. Mr. Jacobson will later report on the corrosion resistance of the uranium alloys.

Gas Elimination

It has been determined that hydrogen in excess of the amounts given in the specification will adversely affect the ductility as measured by the percent elongation and reduction of area.

The following heat treatment has been developed to remove hydrogen in the uranium 8%Mo alloys:

900°F - 4 hours (time depending upon section size)

1650°F - 2 hours WQ

This treatment will result in a reduced yield strength but will remove the excess gases and restore the ductility to acceptable levels.

Most heats during the alloy-development program contain less than 1 part per million hydrogen and less than 100 ppm oxygen.

Metallographic

Limited metallographic studies have been conducted on the U-8%Mo and U-8%Mo-1%Ti alloys. Results indicate that both of these alloys are single phase. Typical microstructures are presented in Figures 3, 4, and 10 and show structures of as-cast, extruded, and "cold worked" alloys respectively. (Note the reduced grain size in the extruded condition).

Further metallographic studies will be made on these and other alloys in the heat-treated conditions as well as material worked below the recrystallization temperatures.

7 June 1960
WATERTOWN ARSENAL LABORATORIES

TABLE I

EFFECT OF CARBON CONTENT ON DUCTILITY AS-CAST U-8 MO

?PM)	ELONGATION(%)	R. A. (%)
!0	10	28
)0	10	21
'0	9	20
;0	10	20
;0	10	21
'0	7	18
)0	8	17
)0	7	14
;0	6	13
!0	4	9
.0	3	5.5
)0	3	6.5
.0	3	3.6
.0	4.2	5.7
)	2.0	2.6
!0	2.1	4.5
:0	0	0
)0	1.4	2.1
)0	0	0

TABLE II

U-ALLOY - -L-93 HEAT TREATMENT 2%Mo-2%Zr-2%Cb-1/2%Ti

t Treatment	.1% Y. S. (Psi)	T. S. (Psi)	% Elon.	% R. A.	Charpy Impact -40°F (ft-lbs)
0°F W.Q.	35,000	139,000	17	22	16.0
0°F W.Q. 900°F r. W.Q.	248,000	264,000	3	7.2	2.7
Cast	194,000	210,000	0	0	3.4
Extruded	164,000	221,000	8	16.2	6.8

TABLE III (a)

MECHANICAL PROPERTIES OF
U-8% MO AS-CAST

Heat No.	Y. S. @.1	T. S.	Elon.	R. A.	Charpy Impact at -40°F
L 3	130	131	4.5	5.7	3.9
L 11	118	*	0	0	2.1
	119	122	2.0	2.6	2.2
L 13	123	127	4.0	8.0	2.1
	118	128	0	0	2.3
L 22	116	120	1.0	2.1	1.0
	118	124	*	*	0.5
L 23	106	114	3.0	3.4	3.1
	121	121	0	0	3.4
L 24	126	128	3.0	5.6	2.8
	125	128	5.0	12.6	3.0
L 33	119	123	11.0	36.0	3.0
	112**	114**	4.0**	10.4**	-

* Specimen broke in threads.
** Imperfection in tensile specimen.
*** Specimen broke before .1% yield took place.

Heat No.	Y. S. @.1	T. S.	Elon.	R. A.	Charpy Impact at -40°F
L 36	118	121	2.0	3.4	3.1
	120	128	8.0	15.6	3.0
	116	124	6.0	12.6	3.2
L 38	118	124	7.0	14.0	4.5
	116	124	8.5	24.0	5.0
L 45-Mullite Wash	118	120	1.0	2.0	2.5
	122	129	4.0	6.3	3.2
L 51-Mullite Wash	121	122	2.0	2.6	2.8
L 52-Mullite Wash	***	113	0.0	0.0	1.9
L 53-Mullite Wash	120	125	2.0	2.6	2.4

TABLE III (a) (Cont)

Heat No.	Y. S. 0.1	T. S.	Elon.	R. A.	Charpy Impact at -40°F
L 55-Mullite Wash	126	123	3.0	4.2	3.0
L 56	118	121	11.0	22.6	3.5
L 57	116	120	9.0	23.4	2.9

* Specimen broke before .1% yield took place.
** Imperfection in tensile specimen.
*** Specimen broke in thread.

Heat No.	Y. S. 0.1	T. S.	Elon.	R. A.	Charpy Impact at -40°F
L 58	121	126	5.0	7.2	-
L 59	115	119	10.0	26.0	3.0
L 60	116	120	7.0	17.7	3.5
L 61	120	121	10.0	18.4	3.75
L 62	115	121	9.0	22.2	4.1
L 63	118	124	10.0	24.7	3.8
L 64	-	123	10.0	25	4.0
L 65	118	122	8.0	25.4	6.2
L 67	118	118	11.0	30.8	4.0
L 68	119	123	8.0	17.0	3.7
L 70	116	118	12.0	21.8	3.7
L 71	116	118	9.0	17.7	3.8
L 72	118	120	8.0	17.7	3.8
L 73	124	127	5.0	11.8	3.6
L 74	130	131	10.0	22.6	3.0
L 78	121	123	7.0	14.0	3.2

TABLE III (b)

MECHANICAL PROPERTIES OF U-5% MO AS-FORGED

Heat No.	Y. S. 0.1	T. S.	Elon.	R. A.	Charpy Impact at -40°F
L 40	135	137	12.0	42.4	5.5
L 51	134	136	14.0	55.2	8.3
L 52	134	140	14.0	52.6	3.4
L 54	136	142	13.0	42.8	5.2
L 56	136	139	14.0	45.2	6.8
L 57	133	136	15.0	50.4	9.0
L 58	132	136	13.5	47	4.0
L 62	121	131	12	48.7	5.0
L 74	136	136	13.0	59.9	5.5
	136	137	14.0	49.2	-
***	147	151	5.0	41.6	6.0

* Specimen broke in thread.
** Imperfections in tensile specimen.
*** Specimen broke before .1% yield took place.

TABLE III (c)

MECHANICAL PROPERTIES OF U-8% MO AS-ROLLED

L 61	137	138	13.0	49.2	4.5
	135	137	16.0	50.8	5.0
	134	135	14.0	46.2	-
L 66	133	149	14.0	50.8	12.5
	133	136	14.0	52.6	11.0
L 72	138	139	14.0	42.4	10.0

TABLE III (d)

MECHANICAL PROPERTIES OF U-8% MO AS-EXTRUDED

L 78	140	141	10	37.8	2.5
	138	139	10	38.6	5.0
L 79	143	146	14	53.0	5.9
	142	148	13	52.6	4.3

TABLE IV (a)

MECHANICAL PROPERTIES OF U-8% Mo - 1% Ti AS-CAST

Heat No.	Y. S. 0.1	T. S.	Elon.	R. A.	Charpy Impact at -40°F
L 75	128	130	6.0	14.7	3.1
L 76	141	144	10	17	3.2
L 79	130	131	11.0	26.0	3.1
L 85	142	143	10.0	16.2	2.5

TABLE IV (b)

MECHANICAL PROPERTIES OF U-8% Mo - 1% Ti AS-EXTRUDED

L 85	151	154	13.0	37.8	3.4
A (BMC)	146	149	11.0	32.8	2.8
C (BMC)	128	129	10.0	33.4	5.0
F	152	154	12.1	34	2.8
	154	155.8	12.9	38	2.8
G	131	156.8	18.0	42.8	3.2
	132	138.6	12.9	35.8	4.9

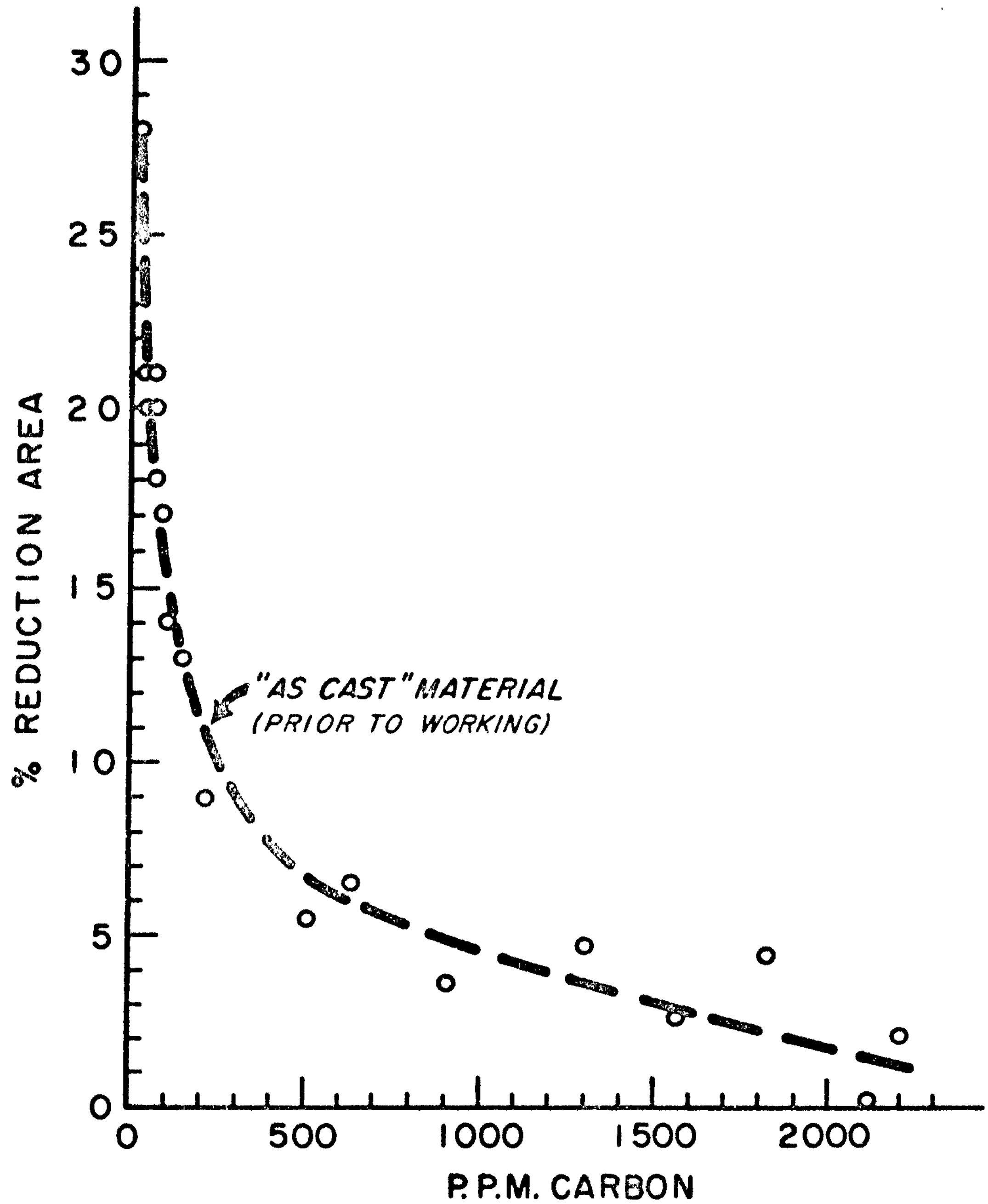
TABLE IV (c)

MECHANICAL PROPERTIES OF U-8% Mo - 1% Ti AS-FORGED

L 76	148	148	17.0	49	4.2
	146	146	16.0	48.6	3.5

AS-CAST URANIUM INGOT

FIGURE 1



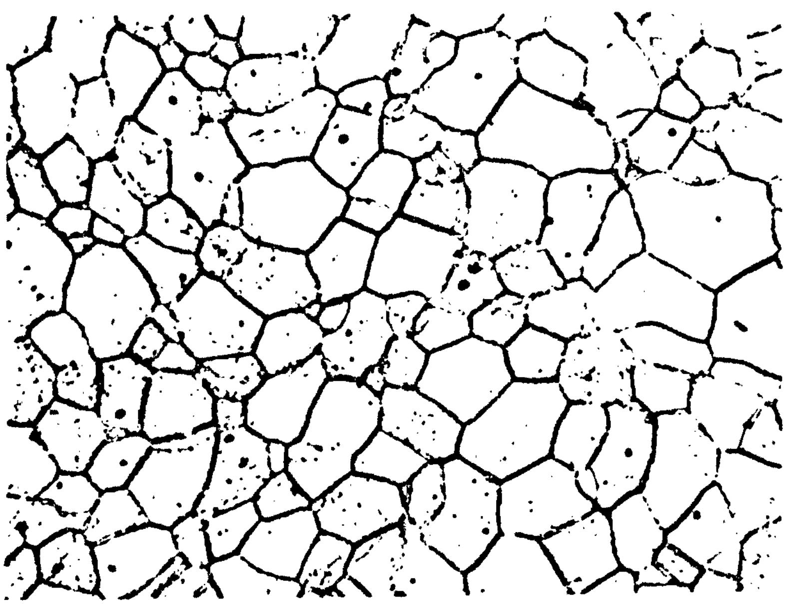
PLOT OF DUCTILITY vs. CARBON CONTENT
URANIUM-8% MOLYBDENUM ALLOYS
AS-CAST

FIGURE 2

500X

MICROSTRUCTURE OF URANIUM - 8% Mo
AS-CAST

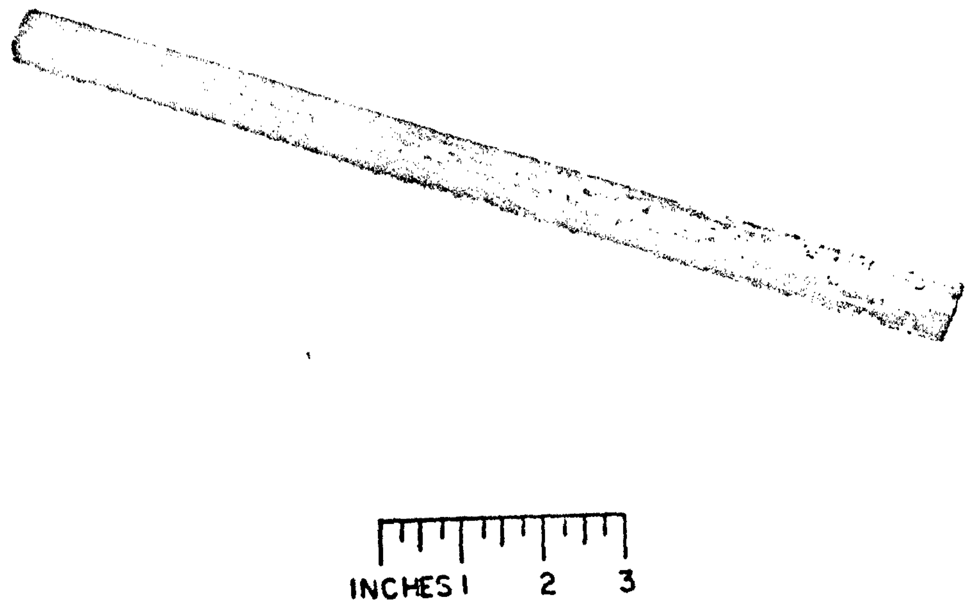
FIGURE 3



500X

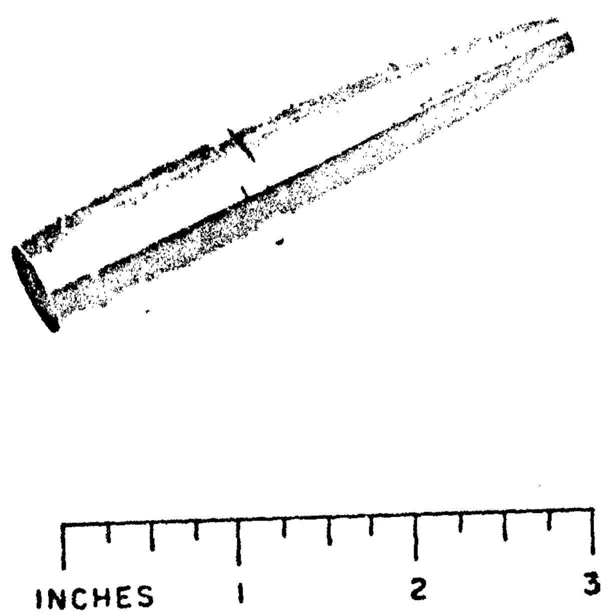
MICROSTRUCTURE OF URANIUM - 8% Mo
AS-EXTRUDED (1650°F)

FIGURE 4



AS-EXTRUDED COPPER COATED URANIUM ROD

FIGURE 5



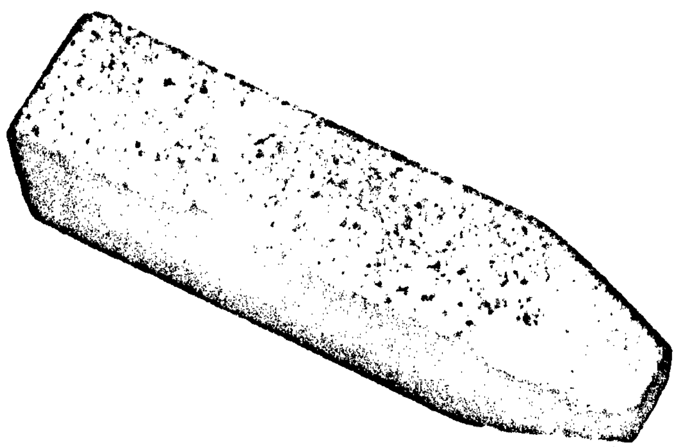
MACHINED URANIUM 20MM SPOTTING ROUND

FIGURE 6

INCHES 1 2 3

AS-EXTRUDED URANIUM CYLINDER

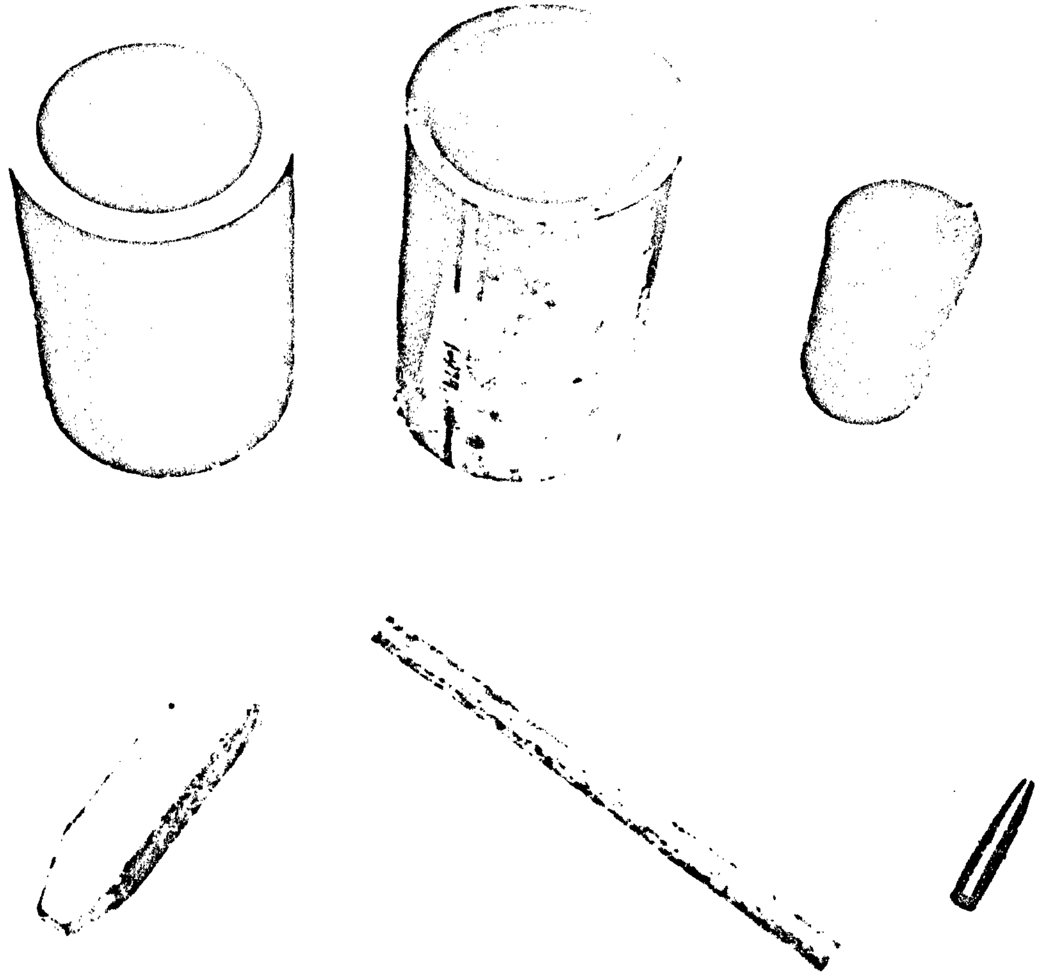
FIGURE 7



INCHES 1 2 3

COPPER COATED (FLAME SPRAYED) URANIUM BILLET PREPARED FOR ROLLING

FIGURE 8



INCHES 1 2 3

HIGH-STRENGTH URANIUM IN VARIOUS STAGES OF PRODUCTION

FIGURE 9

100 X

"COLD-WORKED" MICROSTRUCTURE
URANIUM - 8% Mo - 1% Ti

FIGURE 10

URANIUM ALLOY PROCESSING

by

E. N. Kinas

Introduction

As with most metals used for structural purposes, hot or plastically worked uranium alloys exhibit superior mechanical properties over those obtained from the as-cast material. Specifically, plastic reductions of approximately 50% have been determined as adequate to produce the desired mechanical-property levels.

Equally important in arriving at the desired properties are the proper choice of alloying constituents and melting procedures. Several melting practices currently being evaluated at Watertown Arsenal are described in an article appearing in the February, 1960 issue of Foundry magazine entitled "Uranium Foundry Practice" by O. D. Chandley and D. G. Fleck of Watertown Arsenal. Two alloys, U-8%Mo and U-8%Mo-1%Ti developed at Watertown Arsenal, are capable of meeting these stipulated requirements. Concurrently procedures for the melting of these alloys in moderately large-size heats have been established. In fact, experimental 300-pound heats are being melted at Watertown Arsenal. As an example of even further progress, 2,200-pound heats are being melted by an industrial facility. These 2,200-pound heats will be used in the development of the hot-working processes which are necessary to obtain the desired mechanical-property values. Specifically these processes incorporate extrusion and rolling. For example, two as-cast, solid ingots of 8-1/4" dia. x 6" length or the U-8%Mo-1%Ti alloy and two as-cast, hollow cylinders of 7-3/4" O.D. x 4" I.D. x 10" length of the same alloy will be hot worked at Watertown Arsenal. In the case of the 8-1/4" dia. solid casting, approximately 50% reduction will be imparted to it resulting in a 6-5/8" dia. forged billet. Following this operation the forged billet will be reverse extruded to the desired final configuration. The as-cast hollow cylinder will be forged from its original 7-3/4" O.D. to 6-5/8" O.D. while maintaining the I.D. dimension of 4" through the use of special forging tools. The desired 50% plastic reduction previously mentioned is adhered to in both of these procedures, which assures the obtaining of a sound high-strength component. The following technical data represents processing evalvations conducted over the past year at Watertown Arsenal and what development work is in store for the future.

Processing Procedures Presently Developed

1. Open-Die Forging

Three-inch diameter ingots, 8% molybdenum, were cast at Watertown Arsenal. After degassing (900°F in vacuum for 2 hours) these billets were forged down on open dies at 1600°F to 1" diameter. Both hammer (1500 lbs.) and press (500 ton) were utilized with equal success.

2. Back Extrusion (Solid)

After casting, 6-1/2" dia. billets, 8% molybdenum, were rough machined to 6-3/8" dia. and then reverse extruded in the as-cast condition. To prevent surface tearing that would result in circumferential surface tears as deep as 3/8", hot-rolled 1020 carbon steel sleeves 1/8" thick were used between the extrusion container and the billet. This steel sleeve combined with the molten salt on the billet and the very high die temperature (over 600°F) served to prevent die seizure, reduce billet heat loss, and lubricate the area between the billet and the extrusion container. The type of extrusion punch used was a 4-1/4" dia. drop-off disc type punch made of 9% tungsten hot-die steel heat treated to Rc. 50. Billets were extruded at 1800°F; two types of copper coating were evaluated, copper sprayed (maximum thickness 1/16"), and copper canning using 1/8" thick evacuated copper can. The 1/8" steel sleeves were at the same temperature as the uranium billet (1800°F).

3. Back Extrusion (Tube)

It is essentially the same procedure as the previous method except that the as-cast billet is hollow (3" I.D.). This I.D. is expanded to 4-3/8" I.D. utilizing a special type of expansion drop-off punch made of 4340, heat treated to Rc. 48. Although the amount of reduction by this method is less than that of a solid billet, the problem of center segregation is eliminated.

4. Forward Extrusion

One industrial concern has successfully forward extruded uranium billets from 2.8" dia. to .75" dia. at 1650°F with forward extrusion press setup. This setup was utilized to extrude thirty-eight alloy combinations presently being evaluated at Watertown Arsenal Laboratories for metallurgical and physical properties. It was found that the amount of extrusion pressure required varied for each. The maximum was 580 tons; the minimum was 200 tons. All of the thirty-eight alloys were successfully extruded. These billets were encased in an evacuated copper can 1/16" thick to facilitate extrusion and keep die wear to a minimum.

In both backward extrusion processes the main lubricant used was a mixture of graphite and silicone oil.

5. Rolling

Square billets were rolled at Watertown Arsenal. Two temperatures were utilized, 1300°F and 1450°F. The square cross sections were reduced from 1-1/2" square down to 1/2" square. A copper coating 1/16" thick (sprayed) was used with considerable success.

Future Development

As previously indicated, preliminary rolling study shows that the best mechanical and metallurgical properties for bar stock will be obtained by rolling. The development of processing procedures for rolling has been limited by the limited size and temperature range of heating equipment available at existing licensed industrial rolling facilities in this country. However, a rolling program is in progress to determine the optimum rolling temperatures and time of heating prior to rolling. This program is being conducted by Watertown Arsenal at an industrial concern in Canada. A firm in this country is presently installing a rolling mill and accessory heating equipment suitable for rolling of the high-strength uranium alloys to bar stock and plate.

7 June 1960
WATERTOWN ARSENAL LABORATORIES

SURFACE CHARACTERISTICS

by

M. M. Jacobson

In the development and handling of uranium alloys under the Davy Crockett spotting round program, pyrophoricity and corrosion tendency were recognized as potential problems. The pyrophoric characteristics of uranium, or tendency to ignite spontaneously, may have constituted a serious safety hazard. The uranium alloys to be specified for the Davy Crockett spotting round also were required to exhibit satisfactory resistance to atmospheric corrosion under conditions of long-term storage.

Chips, powder, turnings and drillings of uranium metal are pyrophoric. From a toxicity, handling, and storage standpoint it was evident that care had to be exercised in dealing with finely divided uranium. For example, during machining operations quantities of chips and turnings are not allowed to accumulate but are kept submerged in oil and subsequently disposed of by burning. Massive or solid uranium metal, on the other hand, offers no real problem in handling or storage. From a health physics standpoint it was found, however, that the principal problem was a psychological one--a tenuous fear of this strange new material. This has been effectively overcome, though, in the Watertown Arsenal uranium program through lectures and instruction given to workmen.

It is well known that unalloyed uranium exhibits very poor corrosion resistance even at normal temperatures. It tarnishes or oxidizes very readily in air developing a more or less protective dark brown to black uranium dioxide coating. Unalloyed uranium even oxidizes slowly in a vacuum of 10^{-8} mm. of mercury and in the presence of moisture corrodes very rapidly, following a parabolic growth law. Oxide fracture or dimensional growth of the surface of uranium could present a source of difficulty; consequently the corrosion characteristics of the uranium alloys being developed for the spotting round were an important consideration.

Although the extensive data generated under the Atomic Energy Commission fuel element program indicated that many alloys of uranium possessed remarkably improved corrosion characteristics, study has been underway at Watertown Arsenal to evaluate the corrosion resistance of specific alloys that are being considered for the spotting round because of promising mechanical properties. The objective was to establish corrosion requirements for specification use.

On the basis of surveillance corrosion tests carried out in boiling water on unprotected uranium-alloy specimens, it is proposed to establish

the following tentative requirement: "No weight loss and a weight gain not to exceed 20 milligrams per square decimeter per day."

Corrosion testing in an environment of 50% relative humidity at 160°F is being explored further. Long-time exposure tests are also in progress at ambient temperature as well as corrosion tests of specimens protected with barrier coatings. (Results to date on the influence of barrier organic coatings confirm the Atomic Energy Commission's experience that attempts to enclose uranium may encourage only greater corrosion and that freely circulating air will probably provide the most effective environment for long-term storage.)

Preliminary average data showing comparison of various uranium alloys in the accelerated boiling water corrosion tests are listed in Table I below. Alloys are listed in the relative order of decreasing merit. The increased corrosion resistance of the alloys at the top of the table contrasts strikingly with that for the unalloyed uranium. ("Plus" values indicate a weight gain, and "minus" values a weight loss. Corrosion products were not chemically removed after test.)

TABLE I

CORROSION IN BOILING WATER AFTER 24 HOURS

Material	Corrosion Rate (mdd)
8%Mo-1%Ti	+3
2%Mo-2%Zr-2%Cb-.5%Ti	+6
10%Mo	+16
5%Zr-1.75%Cb	-5
.5%Mo-.5%Cb	-40
2%Ti	-340
2%Mo	--680
Unalloyed uranium	-7000

It is recognized that uranium corrosion is complex and that frequently there may be difficulty in obtaining reproducible data in repeated experiments. Consequently the ratings of several of the intermediate alloys listed in Table I should not be considered as final.

In recent boiling-water corrosion tests conducted on the 8%Mo and 8%Mo-1%Ti uranium alloys wherein specimen preparation and test procedure were defined and controlled very carefully, it has been possible to obtain excellent reproducibility of results--sufficient to warrant inclusion of

the specification requirement of 20 mdd referred to previously. The procedure is described in paragraph 4.5.4 in the proposed uranium specification contained elsewhere in this document.

Corrosion and surface treatment studies are continuing at Watertown Arsenal Laboratories to provide correlation between accelerated and long-term exposures and to ensure complete understanding of possible unusual effects of new alloying elements and influence of new processing variables.

7 June 1960
WATERTOWN ARSENAL LABORATORIES

DISCUSSION AND CHANGES

Proposed Military Specification MIL-U-46045(Ord)
"Uranium Alloy, Wrought, Bars, Billets, and Tubular Shapes"

by

J. F. Coulter

The coordination of a specification between industry and Government is necessary in order that an understanding exists between the parties involved. The requirements of the specification must be technically sound and reasonable.

The particular specification under discussion, based upon considerable materials development, includes such requirements as necessary to purchase the material which will produce an end item, in most cases projectiles.

Since the preparation of the specification some technical areas of the requirements have been found to need adjustments, i.e., hydrogen content, ductility, corrosion rates.

These new values are set out below:

The maximum allowable hydrogen content has been changed from 0.001% to 0.0001% (1 ppm) in paragraph 3.1.

The elongation requirements in Table II have been changed as follows from the values shown:

20	changed to	17
18	" "	15
16	" "	13
14	" "	11
12	" "	9
10	" "	7
8	" "	6

The maximum weight gain value shown in paragraph 3.6 has been changed from 10 mdd to 20 mdd.

In response to a question from an industrial representative, namely, will the melting stock (dingot) used to produce the wrought material be purchased against an Atomic Energy Commission specification? This will be investigated, and if the Atomic Energy Commission specification is suitable it will be used as an applicable document within the specification being considered here.

The materials specification will be rewritten to include the changes shown here, and no further suggested changes were put forward by either Government or industrial representatives.

The specification MIL-U-46045(Ord) dated 24 June 1960 revised to include changes set out as suggested in this discussion is included herein.

7 June 1960
WATERTOWN ARSENAL LABORATORIES

MILITARY SPECIFICATION

URANIUM ALLOY, WROUGHT, BARS, BILLETS, AND TUBULAR SHAPES

1. SCOPE

1.1 Scope. - This specification covers wrought, depleted (see 6.6), unclassified uranium alloy bars, billets, and tubular shapes in section sizes up to 2 1/2 inches for use in Ordnance engineering applications requiring resistance to normal atmospheric corrosion.

1.2 Condition. - Unless otherwise specified in the contract or order, the uranium alloy shall be furnished in the as-rolled, extruded, forged, swaged, or heat-treated condition.

1.3 Finish. - Uranium billets shall be furnished in the rough-turned finish.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bids form a part of this specification to the extent specified herein:

STANDARDS

FEDERAL

FED. TEST METHOD STD. NO. 151 - Metals; Test Methods

MILITARY

MIL-STD-129 - Marking for Shipment and Storage

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. - The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids shall apply.

FSC 9530

AMERICAN SOCIETY FOR TESTING MATERIALS

ASTM Designation: B311-58-Standard Method of Test for Density of Cemented Carbides

ASTM Methods for Chemical Analysis of Metals

(Application for copies should be addressed to the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pennsylvania.)

3. REQUIREMENTS

3.1 Manufacture. - The uranium alloy shall be manufactured using uranium melting stock, of a purity which has been approved by the procuring agency, and such alloying elements as necessary to meet the requirements specified herein (see 3.2, 6.2 and 6.2.1).

3.2 Chemical composition. - Unless otherwise specified in the contract or order, the chemical composition of the uranium alloy shall comply with the range proposed by the contractor. The contractor shall submit a certified analysis of each heat to the procuring agency. The statement of analysis shall include all elements intentionally added as well as the amounts of carbon, iron, oxygen, hydrogen, and nitrogen present as impurities.

3.2.1 Unless otherwise specified, the limits for the elements shown in table I, shall not be exceeded.

Table I - Maximum content for elements present as impurities

Element	Maximum	
	percent	ppm
Carbon	0.015	150
Iron	0.0025	25
Oxygen	0.010	100
Hydrogen	0.0001	1
Nitrogen	0.010	100

3.3 Heat treatment. - When material is heat treated to meet the applicable mechanical property requirements of this specification, the details of the heat treating procedure shall be provided by the contractor and shall be forwarded with each lot at the time of shipment.

3.4 Straightening. - Bows and arcs in the uranium material may be removed by straightening, at the option of the contractor, provided that the temperature of the material during any straightening operation is not less than 1100 degrees Fahrenheit (°F). All straightening shall be performed prior to acceptance testing.

3.5 Mechanical properties.

3.5.1 Tensile properties.

3.5.1.1 Yield strength. - The yield strength range shall be as specified in the contract or order.

3.5.1.1.1 Maximum yield strength. - The specified yield-strength range may be exceeded providing the percent elongation, percent reduction of area, and V-notched Charpy impact resistance do not fall below the values shown in table II for the upper limit of the specified yield-strength range.

Table II - Minimum mechanical property requirements

For yield strength (0.1% offset)	Average elongation	Average reduction of area	Average V-notched Charpy impact resistance at -40°F
p.s.i.	percent	percent	ft.-lbs.
110,000 - 119,999	17	42	6
120,000 - 129,999	15	38	5
130,000 - 139,999	13	34	5
140,000 - 149,999	11	30	4
150,000 - 159,999	9	28	4
160,000 - 169,999	7	26	4
170,000 - 180,000	6	24	4

3.5.1.2 Ductility. - The percent reduction of area and percent elongation shall be as shown in table II for the applicable yield strength range.

3.5.2 Impact resistance. - The V-notched Charpy impact resistance shall be as shown in table II for the applicable yield strength range.

3.6 Density. - The density of the uranium alloy shall be 17.5 ± 0.4 grams per cubic centimeter. Certification of the density shall be provided by the contractor.

3.7 Corrosion resistance. - The corrosion specimens, when tested in accordance with 4.5.4, shall show no weight loss and a weight gain not to exceed 20 milligrams per square decimeter per day (mdd).

3.8 Dimensions and dimensional tolerances. - Dimensions and dimensional tolerances shall be as specified in the contract or order.

3.9 Straightness tolerance. - The straightness of the uranium alloy material shall not vary more than 1/4 inch from the longitudinal axis in any 5 feet.

3.10 Identification marking. - Unless otherwise specified, each piece shall be legibly and indelibly marked with the number of this specification, manufacturer's identification, the piece number, condition and heat number or designation. Physical marking of the uranium alloy material shall be accomplished in a manner which will not be deleterious to the material.

3.11 Workmanship. - The uranium alloy shall be uniform in quality and condition and shall be free from cracks, inclusions, seams, laminations, scale and other defects which would detrimentally affect the suitability of the material for the intended use.

4. QUALITY ASSURANCE PROVISIONS

4.1 The supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own or any other inspection facilities and services acceptable to the Government. Inspection records of the examination and tests shall be kept complete and available to the Government as specified in the contract or order. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Lot. - Unless otherwise specified in the contract or order, a lot shall consist of all uranium alloy material submitted for inspection at the same time, of the same heat, the same condition, and the same diameter. When heat treated, a lot shall be of the same processing cycle and heat treated at the same time in a batch furnace or shall have passed consecutively through a continuous type of heat-treating process.

4.3 Sampling.

4.3.1 For chemical analysis. - At least one sample for chemical analysis shall be selected from each heat in accordance with method 111 or method 112 of Fed. Test Method Std. No. 151.

4.3.2 For mechanical properties. - Unless otherwise specified in the contract or order, at least one sample for mechanical properties tests shall be selected from each lot of uranium material.

4.4 Examination.

4.4.1 Visual. - All material shall be subject to visual examination for compliance with identification marking (see 3.10) and workmanship requirements (see 3.11).

4.4.2 Dimensional. - All material shall be subject to examination for compliance with dimensional requirements (see 3.8) and straightness requirements (see 3.9).

4.4.3 Preparation for shipment. - Examination shall be made to determine compliance with the requirements for the preparation for shipment (see section 5).

4.5 Tests.

4.5.1 Chemical analysis. - Samples for chemical analysis shall be prepared and tested in accordance with method 111 or method 112 of Fed. Test Method Std. No. 151. In case of dispute, the analysis by method 111 shall be the basis for acceptance or rejection.

4.5.1.1 Determination of oxygen and hydrogen. - The ASTM Method E107-56, for determining oxygen and hydrogen by the Vacuum Fusion Method using the Platinum Flux or similar techniques, or any other applicable methods agreed upon by the contractor and procuring agency, shall be used in determining the percentages of oxygen and hydrogen in the uranium alloy.

4.5.1.2 Determination of nitrogen. - The ASTM Method E120-56, "Chemical Analysis of Titanium and Titanium-Base Alloys" or any other applicable method agreed upon by the contractor and procuring agency shall be used in determining the percentage of nitrogen in the uranium alloy.

4.5.1.3 Determination of carbon. - Carbon content in the uranium alloy shall be determined by the High Frequency Furnace Combustion Method or any other applicable method agreed upon by the contractor and procuring agency (see 6.3).

4.5.2 Mechanical properties tests.

4.5.2.1 Location of specimens. - When the location and orientation of mechanical test specimens is not given in the contract or order or on the applicable drawings, transverse specimens shall be taken so that the longitudinal centerline of the specimen is perpendicular to the longitudinal axis of the piece involved and midway between the surface and center of the section. When it is not possible to obtain transverse specimens, longitudinal specimens may be used.

4.5.2.2 Tension tests. - Unless otherwise specified, at least two tensile test specimens shall be prepared and tested in accordance with method 211 of Fed. Test Method Std. No. 151. The largest obtainable round specimen shown in method 211 should be used except that, at the option of the contractor an R2 specimen may be used. The yield strength shall be determined by the offset method by plotting a stress-strain diagram. The limiting offset shall be 0.10 percent (0.001 inch per inch of gage length). The strain rate shall not exceed 0.005 in./in./min. up to the yield strength at 0.2 percent offset.

4.5.2.2.1 Yield strength. - Except as provided in 3.5.1.1.1, if the average yield strength for all specimens tested is above the minimum of the yield strength range requirements specified in the contract or order, the lot represented will be accepted as having met the requirements for yield strength.

4.5.2.2.2 Ductility. - The percent reduction of area and percent elongation shall be determined as the average of all determinations obtained from tests made in connection with the inspection of a lot of material.

4.5.2.3 Impact tests. - Unless otherwise specified, at least two standard Charpy V-notched impact test specimens shall be prepared and tested in accordance with method 221 of Fed. Test Method Std. No. 151. The temperature of the test specimen at the time of fracture shall be -40°F ± 2°F. The error in the Charpy machine shall not exceed ± 1 ft.-lb. for energy values up to 20 ft.-lbs. or ± 5 percent for energy values over 20 ft.-lbs. when the machine is tested using comparison specimens prepared by Watertown Arsenal (see 6.4). This comparison shall have been made within one year prior to the time of inspection testing.

4.5.2.3.1 Impact resistance. - If the average value for all specimens tested is equal to or above the value given in table II opposite the required yield strength range, the lot will be accepted as having met the requirements for impact resistance.

4.5.3 Density tests. - When required, density tests shall be performed in accordance with ASTM Designation: B311-58. Specimens for this test may be taken from mechanical test samples.

4.5.4 Accelerated corrosion tests. - When required, static corrosion tests shall be conducted as shown in 4.5.4.1 through 4.5.4.2 (see 6.5). Samples for this test may be taken from Charpy V-notched impact test specimens. The samples shall be surface ground to approximately the following dimensions: 0.25 decimeters (length), 0.10 decimeters (width), and 0.025 decimeters (thickness), and the surface area shall be determined.

4.5.4.1 Pretreatment and cleaning of test specimens. - Test specimens shall be vapor-degreased with trichloroethylene and then pickled by immersing in concentrated (approximately 70 percent) nitric acid to remove surface film. The specimens shall be immediately rinsed in distilled water, then in acetone, and shall then be air-dried and placed in a dessicator.

4.5.4.2 Corrosion test procedure. - After approximately 10 minutes, the test specimens shall be removed from the dessicator and weighed to 0.1 milligram and immersed completely in clean 1000 ml. Erlenmeyer-type flasks, each containing 400 ml. of distilled water and sufficient number of glass beads to prevent bumping of the specimens. The solution shall be brought to a boil within 10 minutes and kept at a boil through out the remainder of the test, and the water level maintained by use of a Liebig-type condenser. Duplicate tests shall be conducted using separate flasks and shall be carried out under a pressure of 1 atmosphere for a 24-hour period. After 24 hours, the test specimens shall be removed from the boiling water, rinsed under flowing tap water, rinsed in distilled water and in acetone, air-dried, and placed in a dessicator for approximately 10 minutes before being reweighed. The weight change shall be converted to milligrams per square decimeter per day.

5. PREPARATION FOR DELIVERY

5.1 Preservation and packaging.

5.1.1. Level C. - Cleaning, drying, preservation, and packaging shall be in accordance with the manufacturer's commercial practice.

5.2 Packing.

5.2.1 Level C. - Packing shall be in accordance with commercial practice adequate to insure acceptance and safe delivery by the carrier for the mode of transportation employed.

5.3 Marking. - In addition to any special marking required by the contract or order, shipments shall be marked in accordance with the requirements of Standard MIL-STD-129.

6. NOTES

6.1 Procurement documents should specify the following:

(a) Title, number, and date of this specification.

(b) Condition, if necessary (see 1.2).

(c) Chemical analysis when stipulated (see 3.2).

(d) Yield strength range (see 3.5.1.1).

(e) Dimensions and dimensional tolerances (see 3.7).

(f) Special identification marking not covered in 3.9.

(g) Name of inspecting agency when inspection shall be performed by other than contractor (see 4.1).

(h) Lot size if not as specified in 4.2.

(i) Sampling for mechanical properties tests, if necessary (see 4.3.2).

(j) When tests for density verification are required (see 4.5.3).

(k) When special marking-for-shipment requirements are necessary (see 5.3).

(l) Special Atomic Energy Commission and Interstate Commerce Commission regulations and requirements pertaining to the safety and methods involved in the preservation, packing, marking, and safeguarding of uranium alloy material covered by this specification.

6.2 The following uranium alloys are recommended for use with this specification:

Uranium (92%) --- molybdenum (8%) and
Uranium (91%) --- molybdenum (8%) --- titanium (1%).

6.2.1 It has been determined that uranium melting stock having the degree of purity indicated below, is capable of producing alloys which consistently meet the physical and mechanical properties specified herein:

Element	Content (ppm)	Element	Content (ppm)
C	50 (approx)	Ni, Si	30
H	<1	Cr, Mn, Mg	2
O, V, Ca	20	Co	4
N, Al	10	Li, Be	0.2
Fe, Cu	15	B	0.4

6.3 The method referred to in 4.5.1.3 is shown in Information Bulletin No. T8, Part II, issued by the Metallurgical Advisory Committee on Titanium, on pp. 12-19.

6.4 Information regarding comparison tests on Charpy impact machines employing Watertown Arsenal comparison specimens can be obtained from the local Ordnance District or from the Commanding Officer, Watertown Arsenal, Watertown 72, Massachusetts.

6.5 The contractor will not ordinarily be required to perform corrosion tests on acceptable uranium alloys previously tested and reported in literature.

6.6 Definition.

6.6.1 Depleted. - Depleted uranium is uranium having less than 0.7% of the U_{235} isotope, the amount found in "normal" or "natural" uranium.

NOTICE: When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or the other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

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Army - Ordnance Corps

Preparing Activity:

Army - Ordnance Corps

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CONTROL
AND
ACCOUNTABILITY
OF
S. S. MATERIAL

WATERTOWN ARSENAL
WATERTOWN, MASS.

CONTROL AND ACCOUNTABILITY OF SS MATERIAL
LIST OF PARTICIPATING PERSONNEL

Function	Name	Position
Health Physicist	J. D. Murphy	Asst Health Physicist - WA
SS Accountability Rep.	P. V. Riffin	Chf. Ord Materials Br - WAL
SS Accountability Rep. Alternate	E. M. Shebek	Chf. Materials Office - WA
SS Responsible Rep. WAL	J. A. Misencik	Metallurgist - WAL
SS Responsible Rep. AOD	D. G. Fleck	Metallurgist - AOD
SS Responsible Rep. AOD	G. D. Chandley	Chf. Foundry Br. - AOD
Accountability Records	M. F. Flaherty	Program Office - WAL
RD Control Officer	P. O. McManus	Sec. Adm. - WAL
RD Control Officer Alternate	C. R. Forguites	Deputy Chf I&S - WA

CHAPTER 700001

RADIOLOGICAL SAFETY POLICY

1. Purpose

1.1 The purpose of this chapter is to prescribe Watertown Arsenal safety policies pertaining to ionizing radiations.

2. Scope

2.1 The provisions of this chapter encompass the responsibilities for and implementation of the arsenal's radiological safety program and apply to all organizations.

3. Definitions

3.1 Ionizing radiations mean any and all of the following: alpha rays, beta rays, gamma rays, x-rays, neutrons, high speed electrons, high speed protons, and other atomic particles, but not sound or radio waves, visible infrared, or ultraviolet light.

3.11 Hazardous ionizing radiations are those of sufficient intensity to possibly cause adverse biological effects.

3.12 Radioactive materials are those which spontaneously emit ionizing radiations.

3.13 Radiation areas are those arsenal areas where personnel may be exposed to ionizing radiations.

4. Responsibilities

4.1 The Radiological Safety Committee has staff responsibility for advising the Commanding Officer on overall policy matters pertaining to Radiological safety, establishment of arsenal wide radiological safety policy and program, coordinating the various safety aspects, and resolving conflicts that may develop on the radiological safety program.

4.2 The Health Physicist is responsible to the Commanding Officer for: (a) formulating radiological safety policies; (b) carrying out the arsenal Radiological Safety Program; (c) reviewing and approving arsenal wide and internal operating procedures for protection against ionizing radiations; (d) authorizing deviations from approved

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procedures because of emergency or temporary circumstances; (e) consulting with and advising staff and operating organizations; (f) inspecting and surveying approved health physics operations being performed by operating organizations; (g) recommending allowable contamination levels and monitoring activities to insure that such levels are not exceeded; (h) carrying out radioactive waste disposal program.

4.3 The Civilian Medical Officer is responsible for all medical aspects of the Radiological Safety Program including the surveillance and health maintenance of all personnel exposed to hazardous ionizing radiations, maintenance of employee radiological safety records in accordance with AR 40-580, and all other applicable regulations.

4.4 The Safety Officer is responsible for all safety aspects of the Radiological Safety Program other than radiological safety.

4.5 The Fire Marshal is responsible for the administration and carrying out of the fire protection aspects of the Radiological Safety Program.

4.6 Chiefs of operating organizations utilizing radioactive materiels, and/or equipment which generate hazardous ionizing radiations, and/or control areas where exposure to hazardous ionizing radiations is possible are responsible for: (a) the formulation of cogent operating procedures for each relevation application and their approval; (b) compliance with and enforcement of established Watertown Arsenal policies and approved operating procedures; (c) assisting, where necessary, the Health Physicist in conducting radiation monitoring activities to insure compliance with established radiological safety standards.

5. Implementation

5.1 Chiefs of organizational units are responsible for the preparation of internal operating procedures for the proposed utilization of radioactive material or other sources of ionizing radiations and will forward such procedures to the Health Physicist for review and approval prior to official publication, and providing personnel to the Health Physicist as necessary in carrying out the Radiological Safety Program.

5.11 Supporting offices including the Materials Office, Intelligence and Security Office, and Plant Facilities Office will review drafts of all procedures and, if necessary, will prepare necessary additional internal operating procedures for their

activities.

5.12 Procedures or problems concerning the utilization of additional space in connection with the Radiological Safety Program will be routed to the Assistant for Plans and Programs.

CHAPTER 701002

URANIUM PROGRAMS

Section A - General

1. Purpose

1.1 This chapter outlines the procedures to be followed for the utilization of radioactive materials, equipment or facilities used in conjunction with the uranium programs, and includes the receipt, issue, accountability, responsibility, safe storage and processing of uranium, and the disposal of its waste products.

2. Scope

2.1 The provisions of this chapter apply to all organizations of the arsenal handling or using uranium in their operations, and to all personnel engaged in these operations.

3. Policy

3.1 *All pertinent Sections of Part 2, WA Manual, Chapter 700000, Radiation Safety Program" will be adhered to.*

3.2 *All technical matters pertaining to health physics will be channeled through the Health Physicist for decision or recommendations to the Radiological Safety Committee in accordance with Radiation Safety Policy, Part 2, Chapter 700001.*

3.3 *Arsenal organizations handling uranium in their operations will process required health forms and such follow-up reports as are required and forward them to the Health Physicist, and carry out the Health Physics Safety aspects of this program for which their organization has operating responsibility.*

3.4 *All radiological safety measures will be approved by the Health Physicist and will be rigidly followed by all organizations.*

3.5 *Reporting requirements established by the Atomic Energy Commission are the responsibility of the S.S. Accountability Representative.*

4. Definitions

a. Source Material - Any material except special nuclear

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material, which contains by weight one-twentieth of one percent (0.05%) or more of (a) uranium, (b) thorium, or (c) any combination thereof.

b. Special Nuclear Material - means special nuclear material as defined in Section II of the Atomic Energy Act of 1954 and regulations which may be issued pursuant to that Act by the AEC.

c. S.S. Material - includes "source material" and "special nuclear material" as defined above and those other materials to which Chapter 7401 of the AEC Manual apply.

5. Security Measures

5.1 Depleted uranium which is classified, or projects in a classified category, and reports pertaining thereto, will be handled in accordance with the provisions of AR 380-5.

Section B - Allocation, Procurement, and Receipt of Uranium

1. Purpose

1.1 The purpose of this section is to prescribe the procedures to be followed for obtaining allocation of uranium from the Atomic Energy Commission, procurement of uranium, and receipt of uranium at this arsenal.

2. Scope

2.1 The provisions of this section apply to the Procurement and Supply Branches of the Materials Office, the SS Accountability Representative, operating organizations, the SS Material Responsible Officers of arsenal operating organizations, WA Laboratories Program Office, Health Physicist and the RD Control Officer.

3. Policy

3.1 The SS Accountability Representative will approve all stores issues for uranium prior to their being forwarded to the Procurement Branch for action.

3.2 All deliveries of radioactive and SS Material requisitioned by the arsenal will be consigned only to the SS Accountability Representative after having been monitored by the Health Physicist. All Stores Issues and Purchase Orders processed will be marked "Deliver to SS Accountability Representative". The name of the designated individual will be used.

3.3 The Procurement Branch will be responsible for initiating procurement actions and their follow-up and will establish controls to assure that required documents and material are given the most expeditious action possible.

3.4 Shipments of SS Material will not be opened at the storehouse.

3.5 No SS Material shipments will be opened until the SF Shipping Form AEC 101 is received at the arsenal.

3.6 All weights of SS Material will be listed in pounds to nearest tenth. It will be the responsibility of the WA Laboratories Program Office to convert the weights to kilograms for required external reports.

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4. Processing Stores Issues

4.1 Arsenal organizations who need to order uranium for assigned projects will prepare Stores Issues in accordance with written procedures; in addition Stores Issues will contain the typed lines:

"Issue approved by SS Accountability Representative"

(Signature) ____________________

"To be issued only to SS Accountability Representative"

4.11 If additional technical information is required that cannot be included on the Stores Issue, a typed page will be attached to the Stores Issue.

4.2 All Stores Issues for SS material will be forwarded to the SS Accountability Representative who will then request the allocation.

5. Obtaining Allocation from San Francisco Operations Office

5.1 The SS Accountability Representative will request allocation of uranium from the Atomic Energy Commission after receiving written justification from requisitioner. This justification will include the concurrence of the Watertown Arsenal representative responsible for the specific project at this arsenal.

5.2 Upon the basis of written justification approval, the SS Accountability Representative will immediately contact the San Francisco Atomic Energy Commission Office by telephone, teletype or letter setting forth needs and requesting allocation for the required material. The contact point is:

Chief, Materials Management Branch
Technical Operations Division
U. S. AEC Operations Office
San Francisco OperationsOffice

5.3 Upon assignment of the allocation by the San Francisco Operations Office to the AEC Operation Office at Oak Ridge, the latter notifies the SS Accountability Representative who in turn, releases Stores Issues with vendor's name(s) included to Procurement Branch for action.

6. Processing Purchase Orders

6.1 Upon receipt of the approved Stores Issue from the SS Accountability Representative, the Procurement Branch negotiates with the source(s) designated, prepares the required number of Purchase Orders to cover all of the plants involved in the fulfillment of the requirements of the order so that processing charges, special handling charges, and shipping costs are covered.

6.2 In addition to the normal distribution of Purchase Orders made in accordance with standing operating procedures, one additional copy will be forwarded to the SS Accountability Representative and two copies to the requisitioner.

6.3 The Purchase Order master will be sent to the SS Accountability Representative and will be completed as the Receiving Report upon receipt of the material by personnel designated to inspect and accept SS Material.

7. Follow up on Material and Documents

7.1 The Procurement Branch will establish a follow up system for all actions pertaining to SS Material. This will include material SF Shipping Form AEC 101 and other documents.

7.11 Procurement Br. personnel will be specifically designated and trained in the processing of all stages of paperwork and the steps required for each purchase order for uranium.

8. Receipt of SS Material by Supply Branch

8.1 Shipments of SS material arriving at the arsenal, which are identified by a "Danger-Radioactive" label as prescribed by I.C.C. regulations, will be entered on the Daily Blotter by the Supply Branch personnel.

8.2 Immediately upon receipt of SS material, Supply Branch personnel will notify the SS Accountability Representative and the Health Physicist, or their alternates, of the arrival of the material.

8.3 The shipment will be monitored at the Supply Branch by the Health Physicist or his alternate to check conformity to label in order to avoid contamination in the event radiation factors posted on label and those monitored do not agree. If approved, the shipment will be delivered to the Uranium Storage area designated by the SS Accountability Representative.

8.4 Supply Branch personnel will prepare a Bulk Tally-out for all SS Material received which will list number of containers and gross weight. This will accompany shipment to designated Uranium Storage area. Receiver will acknowledge on original copy and return Bulk Tally out to Supply Branch, Chief Storage Section for suspense pending receipt of White Stores Issue.

9. Receipt by SS Accountability Representative

9.1 Upon arrival at the designated Uranium Storage area, the SS Accountability Representative will determine that the authorized SF Shipping Form AEC 101 has been received.

9.2 If SF Shipping Form AEC 101 has not been received, shipment will remain unopened and the SS Accountability Representative will notify Procurement Branch who will initiate an immediate intensive follow-up to secure the required documents by the fastest possible means.

9.3 When SF Shipping Form AEC 101 has been received, the SS Accountability Representative or his alternate will check in the material, verify the piece count, the weight, type of material and record the required data.

9.4 Weights and lot numbers will be printed or stamped on the respective containers and/or on each individual piece as an aid to subsequent issuing. Lot numbers will be assigned by the SS Accountability Representative.

9.5 SS Accountability Representative will send the completed master of the Receiving Report and a copy of the White Stores Issue to Chief, Storage Section, Supply Branch.

9.6 SS Accountability Representative will receive the No. 3 copy of the White Stores Issue annotated with the voucher number from the Supply Branch and forward it with the SF Shipping Form AEC 101 to the WA Laboratories Program Office. These are the official documents which establish the account.

Section C - Accountability for Uranium

1. Purpose

1.1 The purpose of this section is to prescribe the complete accountability for SS Material which includes establishment and maintenance of required records and preparing reports which are based on these records.

2. Scope

2.1 The provisions of this section apply principally to the WA Laboratories Program Office with feeder information and/or vouchered documents furnished to them by the SS Accountability Representative and arsenal operating organizations who participate in the uranium programs.

3. Policy

3.1 For weighing operations, all organizations sending or receiving uranium will use the same standard type scales with weights to tenths of lbs. Scales will be tested every six months or when discrepancies occur. A test block will be provided with weight verified by Inspection Office.

3.2 Using organizations will take monthly physical inventories of Uranium alloting sufficient time from operations to perform this accurately. The SS Accountability Representative or his designee will take a physical inventory every six months to assure accurate records.

3.3 Classification of all SS Material will be noted on all Uranium Transfer/Issue Record ORDBE 1278R in order to alert all recipients of security classification.

3.4 SS Material of different classifications will not be mixed in processing.

4. Responsibilities

4.1 The WA Laboratories Program Office is responsible for establishing and maintaining adequate and accurate accountability records and for preparing required external reports to the Atomic Energy Commission, Alberquerque Operations Office.

4.2 The SS Accountability Representative is responsible for providing the WA Laboratories Program Office with documents necessary to maintain records of all receipts, shipments, transfers, disposals and losses, and for approving and signing all reports.

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4.3 Arsenal organizations participating in uranium programs are required to provide the WA Laboratories Program Office with copies of all transaction documents and a monthly Uranium Accountability Record, ORDBE 1329R.

5. Establishing and Maintaining Accountability Records

5.1 The WA Laboratories Program Office will establish accountable property records for SS Material following receipt of the No. 3 copy of the White Stores Issue, and the SF Shipping Form AEC 101 as outlined in Section B, this chapter.

5.2 Upon receipt of the vouchered documents, the WA Laboratories Program Office will record the details of the shipment in the following records:

a. The individual Station Account, SS Transfer Journal, Form AEC 104.

b. Overall Station Total General Ledger.

c. Internal Inventory Control Account Ledger. (Note: "b" and "c" are standard general ledger sheets and use of form will not be required.)

5.21 The SS Transfer Journal (5.2 "a" above) is used as the initial book of entry for external transactions. It will be maintained on a fiscal year basis and totaled by month. The journal segregates transactions by material type, shipments, receipts and station. It accumulates portions of the data necessary for compiling the monthly Material Balance Report.

5.22 The General Ledger (5.2 "b" above) functions as the book of final entry and shows overall station totals. It accumulates portions of the data necessary for compiling the monthly Material Balance Report. Entries are made in date order and the description indicates the posting source data and totals.

5.23 Internal Inventory Control Account Ledger (5.2 "c" above) is used to record the amount of material in inventory and to record the withdrawal of material from inventory to initiate work in process.

5.24 The SS Accountability Representative will maintain a Monthly Accountability Record, ORDBE Form 1329R for all SS Material received and issued from the inventory storage area. Receipts will

include shipments from sources of supply and return from operating organizations of material surplus to their needs.

6. Transactions Affecting Accountability Records

6.1 The SS Transfer Journal will record the following types of transactions based on SF Shipping Form AEC 101:

a. Material received from the individual station (front side of form).

b. Shipments made to individual stations (reverse side of form).

6.2 The Station Total General Ledger will record the following types of transactions:

a. Material received - based on SF Shipping Form AEC 101

b. Shipments made - based on SF Shipping Form AEC 101

c. Book Physical Inventory Differences (B-PID) which are the non-recoverable losses incurred in operations performed on work in process and in burning operations. (Entries are made on the basis of losses reported on Monthly Accountability Report, ORDBE Form 1329R.)

d. The approved inventory write-offs which are the removal from inventory of non-recoverable material and disposal according to regulations. This entry will be based on a Property Turn In for the material which will be prepared by the SS Accountability Representative.

7. Forms Used for Internal Controls

7.1 When material is issued from inventory stock, ORDBE Form 1278R will be signed by the SS Accountability Representative or his designee who will indicate the security classification of the material. All subsequent transfers will carry the security classification.

7.11 ORDBE Form 1278R, Uranium Issue/Transfer Record (Exhibit "A") will be the only form used to issue uranium from inventory, transfer material between organizations, or transfer scrap or sludge from operating organizations to uranium disposal storage area. This form must be signed by the sending and receiving authorized personnel.

7.2 ORDBE Form 1329R, Uranium Accountability Record (Exhibit "B")

will be utilized by all organizations using uranium in their operations. This record will reflect the daily transfers in and out of the organization, and known losses due to melting, forging or other operations. At the end of each month the closing physical inventory will be taken and recorded on this form, the non-recoverable losses determined and explained, and the monthly report completed.

8. Internal Accounting Controls

8.1 Receipts. SS Material received at the WA Laboratories uranium storage area will be recorded by the Program Office in the Internal Inventory Control Account Ledger (par 5.2c this section).

8.2 Processing Uranium Issue/Transfer Record. The following actions will be taken in processing ORDBE Form 1278R.

8.21 Issuance from Inventory. The SS Accountability Representative or his designated representative will be the only authority for issuing uranium from inventory.

8.211 Requests for Uranium will be made to the SS Accountability Representative, Bldg. 39, by memo or telephone by authorized personnel.

8.212 Upon receipt of request, the SS Accountability Representative will prepare the Uranium Issue/Transfer Record, ORDBE 1278R in quadruplicate by entering the required information and signing the form.

8.213 The SS Accountability Representative or his representative will weigh and issue the uranium and forward it with all copies of ORDBE Form 1278R to the requesting organization.

8.214 The receiving organization will verify the weight of the material received and the SS Responsible Representative or his alternate will sign ORDBE Form 1278R and copies of the form will be distributed as marked.

8.3 Posting to Records. The Monthly Accounting Record, ORDBE Form 1329R maintained by the Program Office and the using organizations will be posted on the basis of the information contained on ORDBE Form 1278R. Distribution of ORDBE Form 1278R is as follows:

a. Original Copy. Sender will record the date and voucher number and enter the Net U Weight in the "Transfers Out" column of ORDBE Form 1329R.

b. First Copy. Receiver will record the date and the voucher number and the Net U Weight in "Transfers In" column, of ORDBE Form 1329R.

c. Second Copy. The Program Office will record the issuance to Work in Process in the Internal Inventory Control Accounting Ledger and will record on the receiving organizations Individual Ledger Account, the date, voucher number and the Net U Weight of the material transferred in.

d. Third Copy. For use by Arsenal Operations Division SS Responsible Representative where applicable.

8.4 Transfers Between Organizational Units

8.41 Transfers of uranium between organizations will be made by using ORDBE 1278R. No uranium will be transferred by any organizational unit without using this document and it will be used to record transfers in and transfers out on the records of responsible personnel.

8.42 Transferring organization will prepare ORDBE Form 1278R in quadruplicate and forward all copies with the SS material.

8.43 Receiving organization will verify weight and have the form signed by the SS Responsible Representative and distribute copies as marked.

8.44 Records of the sending and receiving organizations and the Arsenal Operations Division Responsible Representative's records will be posted as outlined in par. 8.3 above.

8.45 WA Laboratories Program Office records will be adjusted to indicate the change in each organizations ledger account. Where both organizations involved in the transfer are within the Arsenal Operations Division no record by WAL Program Office is necessary since this is within the Arsenal Operations Division account and they will maintain their required records.

9. Book Physical Inventory Differences - (B-PId)

9.1 B-PIds are the non-recoverable losses incurred in operations performed in WIP and in burning operations. These can generally be grouped in two categories as follows:

9.11 Known Losses - those occur in such operations as melting, where a known quantity is placed into process and at the completion of

the process that quantity has changed, the difference being the loss resulting from this operational process.

9.12 Estimated Losses - these occur when material is placed into process and it is not possible to accurately determine the exact amount of SS material lost, i.e., where machining operations are involved and health and safety precautions result in evacuation of particles through ventilation processes when loss cannot be measured; in burning operations similar losses are incurred, etc.

9.2 Accounting for Non-Recoverable Losses

9.21 ORDBE Form 1329R provides organization using SS Materials the mechanism for reporting and explaining the non-recoverable losses incurred each month.

9.22 Known losses and weights will be recorded in the appropriate column on the date on which the loss is determined. The type (melting, machining, etc.) will be noted in the "Comment" column. The total of this column at the end of the month will equal the total of the "by difference" column in the Non-Recoverable losses portion of the report.

9.23 Estimated losses will be reported in the column provided in the Non-Recoverable Loss portion of the report.

9.3 The total of the non-recoverable losses of the report will equal the total reported on the line "non-recoverable losses" on the left side of the report.

10.. Accounting for Scrap and Approved Inventory Write-Off

10.1 Generated scrap consists of chips, turnings and sludge resulting from machining and other processes and must be accurately reported and recorded on monthly accountability records.

10.2 All scrap when collected will be turned in to the SS Accountability Representative and it must be transferred on Uranium Issue/Transfer Records ORDBE Form 1278R and recorded on Monthly Accountability Record, ORDBE 1329R.

10.3 Containers of scrap will be clearly marked as to the estimated uranium weight by the SS Responsible Representative of the organization returning the scrap material.

10.4 The SS Accountability Representative will maintain a Monthly Accountability Report, ORDBE 1329R for all material turned in to scrap

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storage. Entries will be made as the scrap is received.

10.41 A record will be made through the use of ORDBE 1278R, Uranium Transfer/Issue Record when scrap is burned and residue is returned to the scrap storage area. In each such case, where a non-recoverable loss is incurred, it will be recorded in the "known losses" column of Monthly Accountability Record, ORDBE 1329R.

10.5 Approved inventory write-offs represent material which is removed from scrap storage and disposed of in accordance with regulations. This generally is accomplished in one of two ways, i.e. disposal at sea or disposal through burial at Oak Ridge, Tennessee.

10.51 Non-Recoverable material which has been cleared for disposal by SS Accountability Representative will be turned in on a Property Turn-In Slip. This will be the voucher document for making entries to the Monthly Accountability Records, ORDBE Form 1329R.

11. Shipment of Finished Goods

11.1 Upon completion of finished items, the operating organizations will prepare a Property Turn-in slip in accordance with published procedures. This will be forwarded to Supply Branch with the finished material. ORDBE Form 1278R will also be prepared and distributed.

11.11 In addition to normal distribution a copy of the Property Turn-in slip will be forwarded to the SS Accountability Representative, Building 39.

11.2 The SS Accountability Representative is responsible for preparing the SS Shipping Form, AEC 101, based on the information contained in the Property Turn-in slip, plus other required technical information. The Supply Branch will provide information required to complete that portion of Form AEC-101 pertaining to shipping voucher number, government bill of lading number, etc.

11.3 The Program Office will bring all copies of Form AEC 101 to the Restricted Data Control Officer, if security classification applies and copies will be distributed in accordance with security regulations. If shipment is not classified, Program Office will distribute copies to the specified destination.

11.4 The Program Office will use Form AEC 101 to make required entries on the Individual Station Account, the Overall Station Total General Ledger and the Internal Inventory Control Account Ledger as

described in paragraph 5, this section. Form AEC 101 will be filed in the Program Office as a supporting voucher to the above entries.

11.5 The Supply Branch will use the Property Turn-In Slip to prepare the Army Shipping Document.

11.51 When the Army Shipping Document is prepared notation will be made on the form that AEC Form 101 is either inclosed in the shipment or will be mailed.

12. Accountability Reporting.

12.1 Atomic Energy Commission regulations require monthly reporting of all SS Material provided to the arsenal. Subject report must be submitted to the AEC Alberquerque Operations Office by the tenth working day following the close of the calendar month.

12.2 The WA Laboratories Program Office is responsible for preparing the consolidated Monthly Accountability Report, AEC Form AL-713, from the Monthly Accountability Reports ORDBE Form 1329R received from operating organizations, and other accountability records. The report will be sent to SS Accountability Representative for signature and distribution.

12.21 Organizations using uranium in their operations are responsible for submitting Monthly Accountability Report, ORDBE Form 1329R to the WA Laboratories Program Office on the last working day of each month. The SS Accountability Representative will prepare two reports, one for SS Material in inventory and the second for scrap in storage.

12.212 No SS Material will be moved between organizations on the last working day of any month while inventory report is being prepared.

12.3 Technical assistance required for the preparation of the consolidated monthly report, AEC Form AL-713, will be provided by The SS Accountability Representative or his designee.

12.4 In instances where Monthly Accountability Reports prepared by organizations, or the consolidated report prepared by WA Laboratories Program Office, do not balance, the SS Accountability Representative will be notified and steps immediately instituted to review all transactions for the month in question until the differences are adjusted. In extreme cases, the SS Accountability Representative is authorized to call for and conduct a special inventory to balance accountability records.

12.5 The SS Accountability Representative will mail the Monthly Accountability Report AEC Form AL-713 to the AEC Alberquerque Operations Office in time for it to reach its destination by the tenth day of the month following the reporting period.

13. Control and Accountability of SS Material

13.1 Exhibit "C" is a flow chart illustrating the actions outlined in Sections B and C of this Chapter

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URANIUM TRANSFER/ISSUE RECORD

TYPE U.: ______________________ VOUCHER NO.: ______________

FORM (SIZE & NO.): ______________________ DATE: ______________

IDENTIFICATION NO.: ______________________ SECURITY CLASSIFICATION ______________

AVERAGE COMPOSITION: ______________________

FROM: ______________________

ORG.: ______________ BLDG. NO. ______

WEIGHT (IN LBS TO 10THS)

TOTAL MATERIAL WT.: ______________

TO: ______________________

% U. CONTENT: ______________

ORG.: ______________ BLDG. NO. ______

NET U. WT.: ______________

SENT BY: ______________________
(RESPONSIBLE OFFICER OR ALTERNATE)

RECEIVED BY: ______________________
(RESPONSIBLE OFFICER OR ALTERNATE)

DISTRIBUTION (RESPONSIBILITY OF SENDER)

WHITE - RETURN TO SENDER
YELLOW - RETAINED BY RECEIVER
PINK - RETURN TO WAL PROGRAM OFFICE
GREEN - SEND TO A.O.D. S.S. RESPONSIBLE OFFICER

ORDER FORM 1329
3 NOV 58 (REV)

URANIUM ACCOUNTABILITY RECORD
(FEEDER FOR A.E.C. R.C.E.-1001)

ORGANIZATION ____________________ MONTH ____________ YEAR ____________

DATE	COMMENT	1 TRANSFERS IN	2 TRANSFERS OUT	3 KNOWN LOSSES
	END OF MONTH TOTALS			

A. OPENING INVENTORY (FROM PREVIOUS MONTH'S REPORT)	
B. TOTAL AVAILABLE DURING MONTH (COL. 1 PLUS A.)	
C. TRANSFERS OUT (COL. 2)	
D. BALANCE (LINE B - LINE C)	
E. CLOSING PHYSICAL INVENTORY (ITEM I)	
F. NON RECOVERABLE LOSSES (LINE D - LINE E)	

INVENTORY AND LOSSES

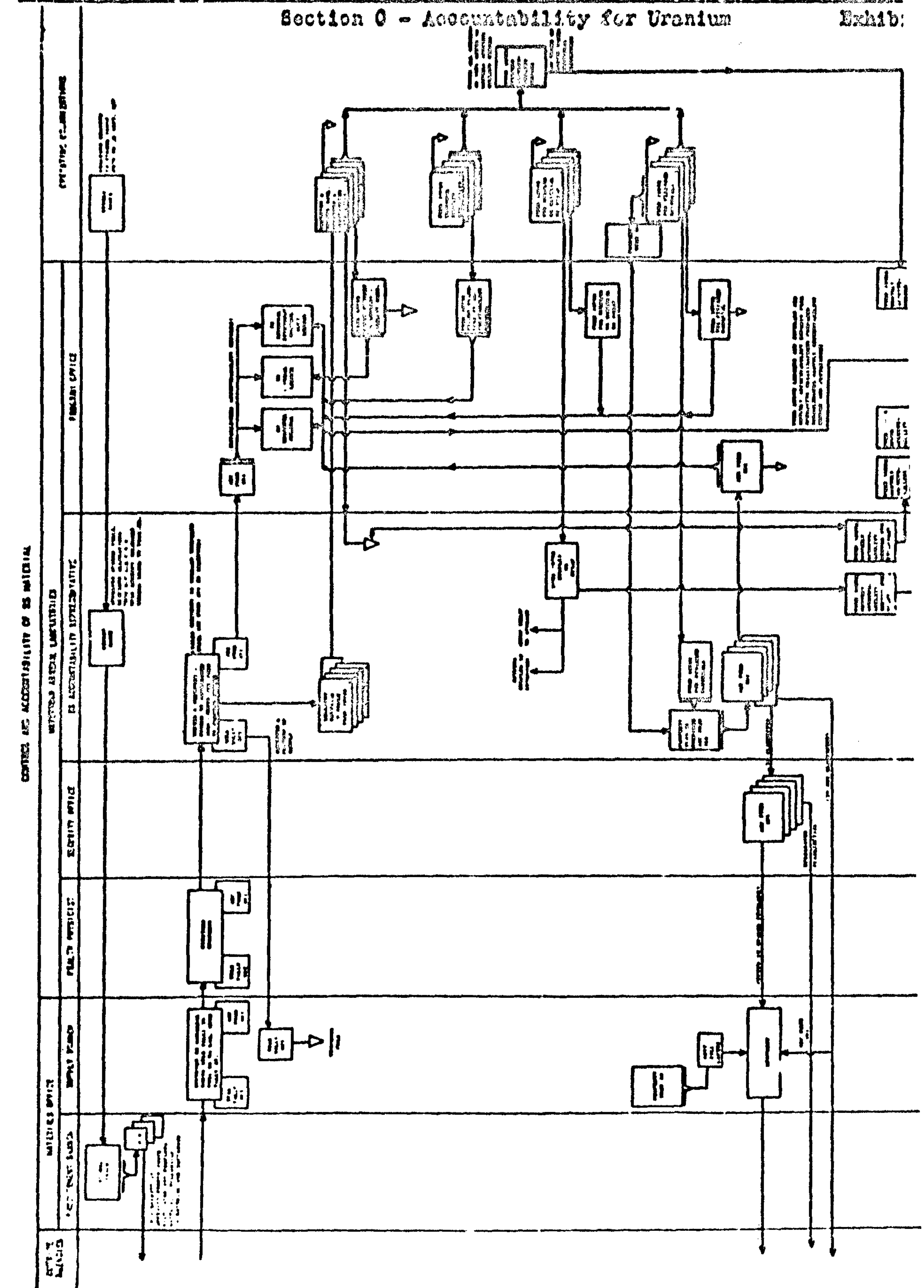
I. CLOSING PHYSICAL INVENTORY ____________
- A. IN STOCK ____________
- B. IN PROCESS ____________
- C. FINISHED PARTS ____________
- D. RECOVERABLE SCRAP (CHIPS ON HAND) ____________

II NON-RECOVERABLE LOSSES:

	EST.	BY DIFFERENCE
A. MELTING		
B. FORGING		
C. MACHINING		
D. OTHER *		
TOTAL		

* EXPLAIN (I.E. MIXED WITH SAND, BURNED, ETC.):

REVISION DATE:
28 Nov 58



Section D - Safety Measures

1. Purpose

1.1 The purpose of this section is to prescribe the safety precautions to be adhered to in the handling of SS Material (Uranium Material) and/or equipment and facilities used on the Uranium Programs.

2. Scope

2.1 This section applies to all uranium material, and/or equipment or facilities used on the Uranium Programs and the provisions outlined will be adhered to by all organizations and individuals who participate in any of the Uranium Programs.

3. Policy and Responsibilities

3.1 Detailed Radiation Safety Policy and the responsibilities of operating and support organizations are spelled out in WA Manual, Part 2 Chapter 701001, which applies to this section or any chapter or section pertaining to hazardous ionizing radiations.

4. Safety Procedures

4.1 Incoming Shipments

4.11 All incoming shipments of uranium are identified by Radioactive Material Class D Poison label, (Annex A).

4.12 Incoming shipments of Uranium Material will not be opened by Supply Branch personnel.

4.121 The Health Physicist or his alternate and the SS Accountability Representative will be immediately notified of arrival of uranium material. Shipment and carrier will be held at Supply Branch until their arrival.

4.122 The Health Physicist will monitor the shipment for radioactivity and to assure that the radiation factors of the material conform to label. If variances exist, the shipment will be under the control of the Health Physicist until he releases it.

4.123 The approved shipment will be transported by truck to the designated SS Accountability Representative who will store it in the specified storage areas until it is issued. If it is classified

Robert R. Lutz
ROBERT R. LUTZ
Lt Col, Ord Corps
Adjutant

DISTRIBUTION:
25A, B

DATE:
12 Jun 58

TM-368

material, it will be stored in assigned locked security area.

4.13 Protective gloves and other protective clothing required will be worn by personnel engaged in receiving, handling or weighing in uranium material.

4.131 Protective clothing will be provided by the Health Physics Coordinators of the various organizations engaged in uranium operations.

4.2 Issue and Transfer of Uranium Material

4.21 Uranium material issued by the SS Accountability Representative, or uranium material transferred between organizational units during processing operations will be transported in approved containers and/or with approved protective covering.

4.22 Issuing and receiving organizational personnel will wear required protective clothing.

4.221 Standards of protection required will be established by the Health Physicist as needed in special situations.

4.23 The material will be stored only in specifically designated areas.

4.3 Machining Radioactive Material

4.31 Machining of uranium materials will be performed on machines designated for this purpose, and these machines will not be used for any but Uranium materials operations. (This does not exclude the finish machining of end items on these machines, utilizing sub-assemblies of Uranium and non-uranium materials, such as sub-assemblies of steel and titanium.)

4.311 When materials other than Uranium are machined on machines within the Uranium machining area, all materials and equipment will be completely decontaminated prior to removal from this area.

4.32 Machines used in processing Uranium material will be so identified and will be segregated in special areas. Machines will not be removed from these areas until they have been completely decontaminated.

4.321 Areas which contain hazardous ionizing radiations caused by uranium material, equipment or facilities will be clearly indicated by appropriate signs as required by regulations.

4.33 All machining operations will be conducted in a very clean shop. Standards of cleanliness will be established by the Health Physicist as needed in special situations.

4.34 During machining operations, machine operators will take all necessary precautionary measures to reduce the possibility of having chips ignite at the lathe. It is recommended that machining be done at minimum practical speed with sharp tools and with generous use of coolant.

4.341 When soluble cutting oils are used in machining of uranium, serious corrosion of lathe beds and other parts of machine tools may develop, particularly if the soluble oil-water mixture is too lean or if the mixture is inadvertently made up by mixing water into the oil. The correct procedure is to add the oil to the water. Corrosion problems will be eliminated by replacing the soluble oil coolant, by water soluble chemical-base coolant, such as "K-7".

4.35 Chips and turnings generated by machining operations will not be allowed to accumulate. Ten gallon buckets with covers are generally recommended and chips and turnings will be submerged in oil (either commercial fuel or mineral oil). Not more than one bucket of the 30 gallon size will be inside a building at any one time.

4.351 As soon as a bucket of chips is accumulated during a working shift, it will be removed from the building and shipped to the designated exterior storage areas.

4.352 Chips and turnings will be removed from all buildings before the end of each working shift and stored in containers in designated outside storage areas.

4.353 Chips and turnings will be segregated by type, i.e. depleted uranium or natural uranium and storage containers will be so identified.

4.354 Chips and turnings derived from classified uranium material will be kept segregated from all other scrap and stored in the classified security area provided for this purpose.

4.36 Sludge in coolant reservoirs will be removed as accumulation requires, or daily if necessary as determined by the Health

Physicist. Sludge will be stored in the same manner as outlined in paragraph 4.35.

4.37 Waste materials (wipers, paper, etc.) will be retained in paper bags provided specifically for this purpose and removed daily to outside storage areas as outlined in paragraph 4.35.

4.38 Solid wastes removed from sink filter traps, vacuum cleaner sweepings, and other sweepings, and exhaust filters will be handled in the same manner as chips and turnings. When any of these involve classified material, they will be stored in classified storage area.

4.39 Machine areas will be policed periodically by the Health Physicist and regularly by the Health Physics Coordinators to insure that safe practices are being maintained and that areas are free of chips and turnings and that these are being removed from the areas as required and being stored properly.

4.40 Decontamination of areas and machines will be performed upon determination of the organization chief or Health Physicist that it is required, or when allowable contamination levels are at or approaching the maximum.

4.4 Ventilating and Exhaust Systems

4.41 One of the prime safety precautions in the machining operations is to provide adequate exhaust and ventilating systems to prevent the ingestion of uranium particles. Machines will be equipped with ventilating and/or exhaust systems.

4.42 Machines will be equipped with required ventilating and exhaust systems operating at a minimum velocity of 150' feet/minute at the chips generating tool.

4.43 Ventilation will be checked with air sample at the normal working area of the machine.

4.44 Buildings which have exhaust systems for uranium machining operations will have the static pressure drop across the filter measured daily. At the same time an air sample (one hour) will be taken in the duct and on the exhaust side of the filters.

4.45 Filters will be changed when either of the following conditions is noted:

a. Static pressure drop across the filter is above 0.25".

b. Air sample of the filter exhaust, monitored by Health Physicist or Health Physics Coordinators, indicates that exhaust is more than ten times background.

5. Film Badges

5.1 All personnel handling uranium will be required to wear film badges and/or dosimeters which are provided to measure rate of radiation exposure.

5.2 Film badges will be under the control of the Health Physicist and distribution to using organizations will be made by his office.

5.3 Chiefs of operating organizations are responsible for assuring that personnel engaged in work involving uranium or hazardous ionizing radiation wear film badges at all times. Health Physics Coordinators of each organization will provide required badges, change film strips as required, take film strip readings and submit reports to the Health Physicist.

5.4 Health Physics Coordinators will be responsible for monitoring admissions to radiation areas as outlined in paragraph 8, Chapter 701000, or to any other areas that may be included in the future.

6. Personnel Precautions

6.1 Protective clothing and shoe protectors will be worn by all personnel who are exposed to radioactive materials in any arsenal area.

6.2 Respirators will also be worn continuously in areas where radioactive dust or radioactive smoke fumes may be present in the air. Such areas will include, but not be limited to, roof exhaust areas and scrap burning areas.

6.3 Personnel who are responsible for changing filters in the exhaust systems will wear gloves.

6.4 Clean protective clothing, shoe protectors, gloves and respirators will be available for all personnel in areas where uranium is being handled. Chiefs of organizations will make arrangements for obtaining or providing these items.

6.5 Protective clothing will be changed daily and after use, at

the end of each shift, soiled or contaminated protective clothing will be placed in containers provided for this purpose.

6.6 Protective clothing will be laundered and/or decontaminated by facilities provided within the arsenal or by approved outside contracted facilities.

6.7 No food, including candy or beverages will be brought into or eaten in any room or area within the installation where hazardous ionizing radiations are present; smoking will be prohibited in areas where unsealed sources of radioactive material are being used, handled, stored, processed or transferred. Specific notice to this effect shall be conspicuously posted in these areas.

6.8 Before eating or drinking outside the restricted areas, hands and face should be washed to prevent ingestion of harmful dusts or other radioactive matter.

Section E - Disposal of Waste Material

1. Purpose

1.1 *The purpose of this section is to prescribe procedures for the disposal of scrap uranium and/or material contaminated with uranium.*

2. Scope

2.1 *The provisions of this section apply to all organizations of the arsenal who participate in the uranium program.*

3. *Policy and Responsibilities

3.1 The Health Physicist is responsible for the uranium waste disposal program, maintaining the necessary radiation protection, determining levels of contamination for various methods of disposal, establishing waste material identification requirements, setting up operating procedures and coordinating disposal program responsibilities.

3.2 The Fire Marshal is responsible for transporting waste materials from organizational units to burning and storage area, converting scrap uranium metal to oxide, incinerating combustible contaminated wastes, and fire protection of storage and burning areas.

3.3 The S.S. Accountability Officer is responsible for necessary accounting procedures, material weights and balances, determination of economical reconvertability and/or salvage value, designation of container, disposition as prescribed by the Health Physicist in accordance with Section B of this chapter.*

4. Personnel Safety

4.1 All personnel engaged in the burning operations must wear film badges during these operations and while in the exposure areas.

4.2 Protective clothing and shoe protection will be worn during burning operations and while residue is being removed.

4.3 Respirators will be worn by personnel participating in the burning operations where radioactive dust or smoke may be present in the air.

4.4 Personnel will not smoke, eat or drink while in the burning area.

4.41 Following burning operations, participating personnel will wash face and hands before smoking, eating or drinking outside the burning area.

5. Area Monitoring Procedures

5.1 Soil samples will be taken periodically in the burning operations area by the Health Physicist to determine the degree of radioactive contamination.

5.11 Soil samples, material immediately analyzed, will be labeled to show location and date, and stored by Health Physicist for future analysis, if necessary.

5.2 *Air samples will be taken during the burning operation at the discretion of the Health Physicist.*

5.3 *The burning area will be monitored during the burning process.*

6. Uranium Metal Scrap

6.1 Chips and turnings generated from machining operations which have been removed from the machine areas and stored in designated exterior storage areas will be collected daily, or as necessary by the Fire Protection Branch.

6.2 Chips and turnings will be transported in their covered containers on fire t[illegible] to the Northeast Area where they will be burned under supervision of Chief, Fire Protection Branch.

6.3 Precautions will be taken to keep air currents from scattering ash residue as all ash must be collected and accounted for.

6.4 Ash residue will be weighed by S.S. Accountability Representative and weight and type marked on containers which will be stored pending disposition instructions. Standards to be followed in disposition will be prescribed by the Health Physicist.

6.5 *Bulk uranium scrap will be stored under oil.*

7. Non-Combustible Waste

7.1 The oil residue in which chips and turnings have been stored will not be dumped on the ground after chips have been removed for burning. This will be returned to WA Laboratories for processing.

7.2 Oil residue will be disposed of by filtering through a 100-mesh screen into the slop sink with adequate dilution or neutralization as prescribed by standards approved by the Health Physicist.

7.21 Solids extracted from the filtering operation outlined in paragraph 7.2 above will be disposed of by burning in accordance with paragraph 6 above.

7.3 *Uranium graphite crucible scrap will be placed in 55 gallon cans and broken to minimize volume requirements.*

7.4 *Saw blades etc. that cannot be easily decontaminated will be stored in 55 gallon drums which are labeled.*

8. Combustible Wastes

8.1 All types of wipers which have been used during machining operations and collected in separate containers will be disposed of by burning as outlined in paragraph 6 above.

8.2 Vacuum sweepings which have been collected during cleaning operations will also be burned as outlined above.

9. Security

9.1 Any waste which may contain classified material will be so marked and stored in the security area which has been provided for this purpose.

Section F - Storage

1. Purpose

1.1 This section defines the procedures to be observed in the storage of uranium.

2. Scope

2.1 The provisions outlined will apply to all organizations who handle and store uranium.

3. Categories of Storage

3.1 The categories of storage defined in this section are:

a. Storage of incoming uranium.

b. Storage of uranium received by using organizations.

c. Storage of work in process containing uranium.

d. Storage of finished work awaiting shipment to Supply Branch for shipment.

e. Storage of uranium waste products and contaminated materials.

f. Storage of recovered waste uranium pending disposition instructions.

g. Storage of environmental samples (soil samples, etc.).

h. Storage of classified material.

4. General Conditions

4.1 All uranium bearing material will be segregated in storage areas except when it is combined with other materials in a component.

4.2 Liquids containing uranium will be stored in separate containers from solids where easily separated; otherwise disposal will be made in bulk.

4.3 Isolated storage areas will be established by all organizations to store any uranium that is not being currently processed. Such areas will be appropriately posted to restrict unauthorized entry. The materials in these areas will be arranged in such a manner to avoid high levels of radiation intensity at any one location.

4.31 Each radiation storage area will be conspicuously posted with a sign or signs bearing the usual radiation caution symbol and the words CAUTION
RADIATION AREA

4.32 Each container in which radioactive material is stored shall bear a durable, clearly visible label bearing the usual radiation caution symbol and the words CAUTION
RADIOACTIVE MATERIAL

4.4 When placed in storage, containers should have a semi-permanent identification including the name of the organization preparing the material for storage, the radioisotopes involved, the level of activity contained therein, and the date when the levels were determined.

4.5 All radioactive material bearing a security classification will be so identified and will be located for storage in the classified security area.

4.6 Access to storage areas will be limited to personnel who have been designated by organization chiefs and who are listed on the Health Physics roster, and who have been cleared for security if the material or project has been classified.

4.7 Film badges will be worn by personnel working in these storage areas.

4.8 Levels of radiation will be measured at periods determined by the Health Physicist to assure that amount of hazardous ionizing radiations does not exceed allowable levels.

5. Rules Governing Various Storage Categories

5.1 Incoming Material. The Supply Branch will establish a segregated storage area, equipped with adequate ventilating and sprinkler system facilities, for the storage of incoming uranium which is not immediately transferred to the using organization. When practical, direct delivery will be made to the using organization after material is checked in by Supply Branch.

5.2 Material Received by Using Organizations. Each organization receiving uranium will arrange suitable segregated areas where material which is not being immediately processed may be stored pending use.

5.3 Work in Process Storage. Components containing uranium which are being machined on a single shift operation will be removed from the machine at the end of the shift and stored off the floor in a five gallon bucket, or other approved container, adjacent to the machine, unless the work is being performed in a classified security area when it may be left in the machine.

5.31 If the material being processed is classified, it will be removed to a locked security area unless the work is being performed in a classified security area.

5.32 If the process involved is a multiple shift operation and will be worked on by successive shifts, the work may be left in the machine set up.

5.33 Where operations are not continuous and there may be a prolonged delay between operations, the material will be located in the storage areas.

5.34 Finished products awaiting disposition will be located in the assigned storage area of the organization completing the work.

5.4 Finished Work Awaiting Shipment. Items on which work has been completed which are sent to the Supply Branch for shipment will be stored in the segregated storage area apart from other materials. If they are classified items, provisions will be made for storage in security areas. If arrangements have been made to have the item shipped from the processing area, the item will be placed in the organization storing area pending shipment.

5.5 Waste Products Storage

5.51 Prior to requesting disposition service for waste products, each arsenal segment having uranium to be disposed of, will comply with the following when accumulated waste has reached the level allowed in the area:

a. Segregate all uranium from non-radioactive material, when practical.

b. Liquid uranium material will be stored in

separate containers from solid uranium material when it can be easily separated.

5.52 Materials will be stored in the established central outdoor isolated storage area which will be appropriately posted to restrict unauthorized entry. The materials in the storage area will be arranged in such a manner as to avoid high levels of intensity at any one location.

5.53 When placed in central outdoor storage, containers should have a semi-permanent identification including the name of the organization preparing the container, the uranium material involved, the level of activity contained therein, the security classification of scrap, and the dates when such levels were determined.

5.54 All waste material bearing a security classification will be stored in locked security storage area.

5.6 Recoverable Waste Material

5.61 Uranium material which has been recovered from any process which has a salvage value will be stored as outlined in paragraph 5.5 above pending receipt of shipping instructions.

5.7 Storage of Environmental Samples

5.71 Soil samples, outlined in Section E, paragraph 6, this chapter, will be stored in segregated storage area by the S.S. Accountability Representative.

5.8 Storage of Classified Material

5.81 All classified uranium material will be stored in locked security areas as outlined in Section G of this chapter.

(ITEM I)
F. NON RECOVERABLE LOSSES
(LINE D - LINE E)

I

DP-BE FORM 1329
3 NOV 58 (REV)

URANIUM ACCOUNTABILITY RECORD
(FEEDER FOR A.E.C. R.C.S.-1001)

ORGANIZATION ______________

MONTH ____________ YEAR ____________

DATE	COMMENT	1 TRANSFERS IN	2 TRANSFERS OUT	3 KNOWN LOSSES
	END OF MONTH TOTALS			
	A. OPENING INVENTORY (FROM PREVIOUS MONTH'S REPORT)			
	B. TOTAL AVAILABLE DURING MONTH (COL. 1 PLUS A.)			

INVENTORY AND LOSSES

I. CLOSING PHYSICAL INVENTORY ____________

A. IN STOCK ____________

B. IN PROCESS ____________

C. FINISHED PARTS ____________

D. RECOVERABLE SCRAP (CHIPS ON HAND) ____________

II NON-RECOVERABLE LOSSES:		EST.	BY DIFFERENCE
A. MELTING	______	______	______
B. FORGING	______	______	______
C. MACHINING	______	______	______
D. OTHER *	______	______	______
TOTAL			

* EXPLAIN (I.E. MIXED WITH SAND, BURNED, ETC.):

MATERIAL: (DEPLETED, NORMAL)

WATERTOWN ARSENAL GENERAL LEDGER

UNITS: KG

	DATE	DESCRIPTION	BEGINNING INVENTORY	RECEIPTS	SHIPMENTS	APPROVED INV. WRITE-OFFS	BOOK-PHYSICAL INV. DIFFERENCES	ENDING INVENTORY	
1									1
2									2
3									3
4									4
5									5
6									6
7									7
8									8
9									9
10									10
11									11
12									12
13									13
14									14
15									15
16									16
17									17
18									18
19									19
20									20
21									21
22									22
23									23
24									24
25									25
26									26

UNITS: .00 of lbs.

MATERIAL: (DEPLETED, NORMAL) INTERNAL INVENTORY CONTROL RESPONSIBLE OFFICER:

COMMENT	DATE	RECEIPTS	TRANSFERS	B-PID'S	ENDING INVENTORY							

WORK IN PROCESS CONTROL

MATERIAL: (DEPLETED, NORMAL) UNITS: .00 of lbs. ORGANIZATION: RESPONSIBLE OFFICER:

COMMENT	DATE	RECEIPTS	TRANSFERS	B-PID'S	ENDING INVENTORY							

U.S. ATOMIC ENERGY COMMISSION

SS TRANSFER JOURNAL

FROM SHIPPER		TO RECEIVER		TRANSFER SERIES
ORGANIZATION		ORGANIZATION		FROM / TO
PERSON		ATTENTION		SS MATERIAL
TITLE		DELIVER TO		
ADDRESS		ADDRESS		

UNITS

MATERIAL DESCRIPTION	SHIPPER'S DATA					RECEIVER'S DATA						SHIPPER—RECEIVER DIFFERENCE			
	Date Shipped	Month		FY To Date		Date Received		Month		FY To Date		Shipper Less		Shipper More	
		SS Net	Net U-235	SS Net	Net U-235			SS Net	Net U-235	SS Net	Net U-235	SS Net	Net U-235	SS Net	Net U-235

SECTION F

HEALTH PHYSICS STUDY DURING FIRING OF URANIUM XM101 PROJECTILE

A. Manufacture of XM101 Projectiles

B. Tactical Use of XM101 Projectiles

  1. Handling and Loading of the Projectile

  2. Firing of the Weapon

  3. Post-Firing Environment and Points of Contact

    a. Breathing Zone of Personnel Using the Weapon

    b. Bore Cleaning

  4. Impact Area

  5. Conclusions

  6. Technical Addendum

Prepared by:

J. D. MURPHY
Health Physicist
Watertown Arsenal

19 February 1960

HEALTH PHYSICS STUDY DURING FIRING OF URANIUM XM101 PROJECTILE

A. Manufacture of XM101 Projectiles

The potential hazards in the manufacturing, i.e., melting, alloying, machining, etc., of the components of the uranium XM101 have been taken care of by the existing standard operating procedures as specified by the Watertown Arsenal Health Physics Office based on the limits as delineated by the Atomic Energy Commission in the Federal Register, 10 CFR, Part 20.

These procedures have been provided to Lake City Arsenal, Aberdeen Proving Ground, and Frankford Arsenal. This cooperative effort has materially expedited the alloy development, manufacturing and application of uranium material. Briefly, health physics studies conducted during melting and machining operations during the past year at Watertown Arsenal have demonstrated that the procedures implemented have effectively controlled the potential hazards to within small fractions of the permissible tolerances.

B. Tactical Use of XM101 Projectiles

1. Handling and Loading of the Projectile

Wipe tests performed on the projectile to evaluate that which could be picked up in handling showed that only extremely minute amounts of radioactive material could be wiped off. The data fall well below the minimum permissible tolerances. Our concern, however, is not for this surface radiation, but from the possibility during handling of it becoming part of the atmosphere. The wiping tests indicate that this is not a problem. The results of these tests are in Graph I. There is no health hazard involved in the handling of the uranium components in the tactical use of the round.

2. Firing of the Weapon

The circumstances of firing are no different from any conventional weapon. Normal operating procedures observed in testing and tactical use of conventional weapons are completely satisfactory for the uranium XM101 projectile.

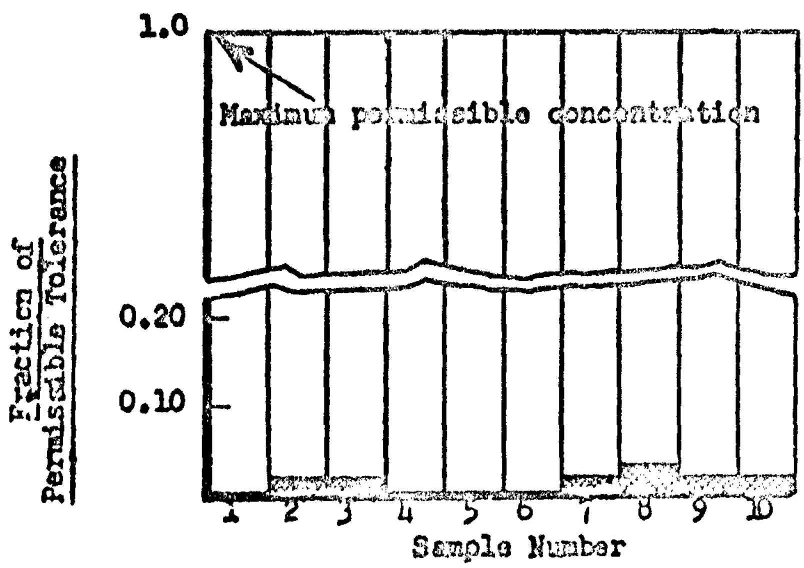
3. Post-Firing Environment and Points of Contact

a. Breathing Zone of Personnel Using the Weapon

The Watertown Arsenal Health Physics Laboratory has experimentally measured the amount of radiation resulting from particles of uranium given off during actual firing. The results as shown in Table 1 and the bar graph II

(shown below) clearly demonstrate that the amount of radiation and hence the amount of uranium particles (dust) given off is negligible. In four out of ten samples taken, no uranium dust could be measured with even the most sensitive instruments, and in all other cases was less than 0.6% (1/160) of maximum permissible tolerance.

In addition, there is no problem of cumulative concentrations in successive firing because of the extremely small amount of uranium material released to the atmosphere.[1]



GRAPH II

b. Bore Cleaning

Wipe tests were made on the bore surface of the gun barrel after firing of one round and after firing four consecutive rounds. One cleaning (wipe) removed all traces of radioactivity after firing one round, and only two cleanings (wiping passes) were required to remove all traces of radioactivity after firing four rounds. Test results are given in Table 2. The data shows that all traces of radioactivity were easily cleaned out.

No epidemiological hazard exists from cleaning the weapon, and the cleaning rags are not active enough to be considered a disposal problem.

---

(1) Recommended limits of exposure to airborne uranium dust as accepted by the Atomic Energy Commission and required under license in accordance with Atomic Energy Commission Regulation 10 CFR, Part 20. 70 dpm/m^3 (disintegration per minute per cubic meter of air) or 50μ gr/m^3 (micrograms per cubic meter of air).

The rags are below that amount which the Atomic Energy Commission would consider contaminated. The recommendations of this author would be to dispose of the rags in any waste container and use standard bore cleaning procedures.

4. Impact Area

Earth samples were taken from Lake City Arsenal and Aberdeen Proving Ground where testing of the uranium XM101 was performed. The earth samples were leached of their uranium with nitric acid solution and evaluated fluorometrically. All concentrations did not vary significantly from what would be expected anywhere on the earth's crust (3 to 9 micrograms of uranium per gram of soil). It has been suggested that the permissible concentration level for soil might safely be set at 100 times the value for water.(2) This suggestion was given by the Health and Safety Laboratory, Atomic Energy Commission, New York Operations Office. It is worth noting that no limit for ground contamination is given in Atomic Energy Commission Regulation 10 CFR, Part 20. It is the recommendation of the Watertown Arsenal Health Physicist that all spotting rounds be left in the impact area and that the impact area not be considered a radiation area. This suggestion was favorably considered by the above-mentioned Atomic Energy Laboratory.

5. Conclusions

The results of the evaluated test data demonstrate that the use of the uranium in the XM101 is not an epidemiological health hazard. The standard operating procedures as exercised in the use of any conventional weapon will be adequate.

6. Technical Addendum

Sampling and Counting Techniques: All air samples were taken, using breathing zone, constant volume air samplers designed by Watertown Arsenal's Health Physics Laboratory. Samples were evaluated with an internal proportional counter on a 2π basis using an argon and methane gas mixture. In order to improve upon the reliability of the measurements extremely long counting times had to be resorted to because of the very low level of radiation encountered in these tests.

Field monitors included geiger counters with anton tubes which incorporate thin-walled geiger tubes which use a halogen quencher. Eberline gas flow, alpha survey meters were also used.

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(2) 1040 micrograms of uranium per gram of soil (parts per million, ppm).

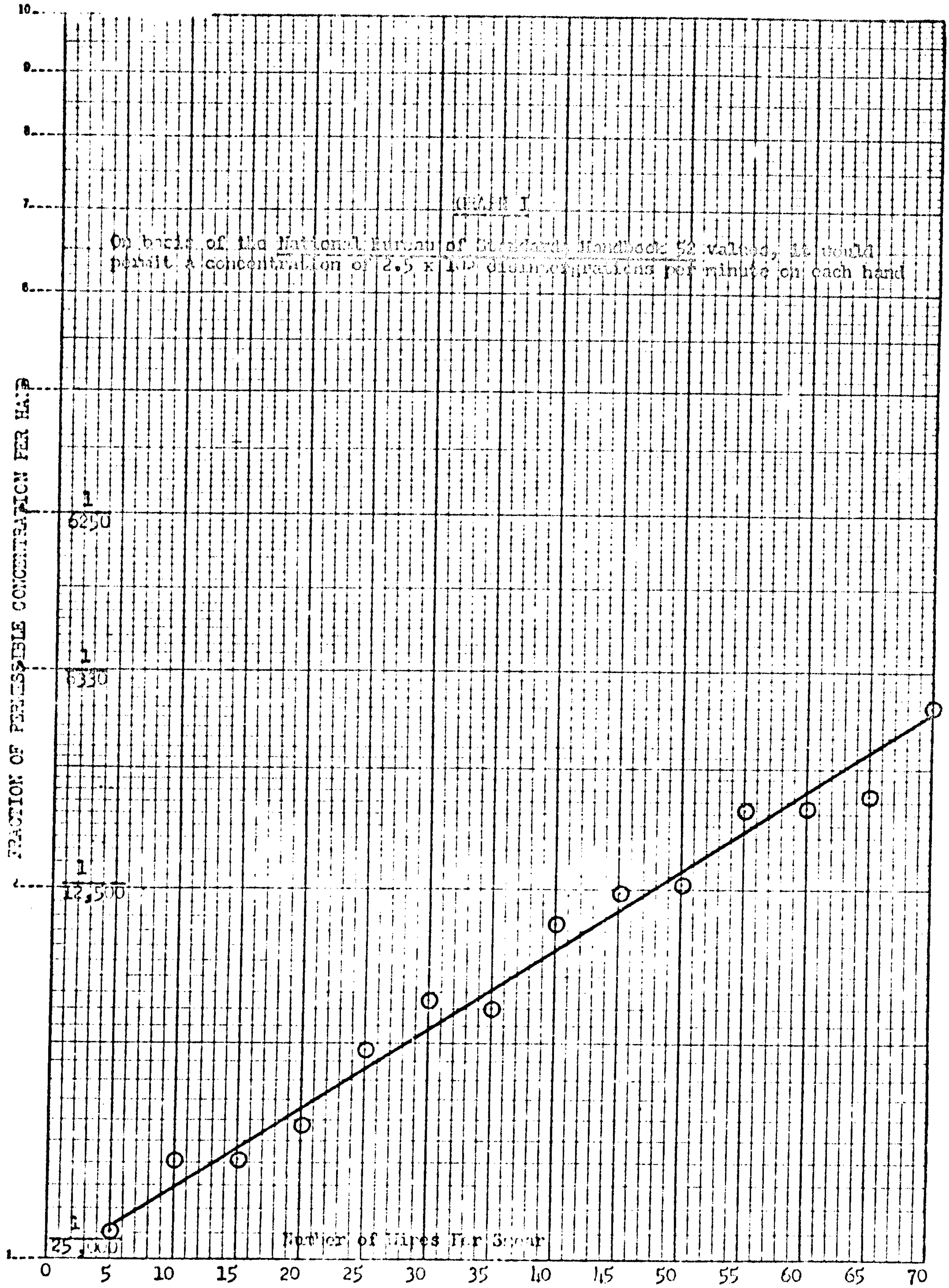
GRAPH I
On basis of the National Bureau of Standards Handbook 52 values, it would permit a concentration of 2.5 x 10⁵ disintegrations per minute on each hand
FRACTION OF PERMISSIBLE CONCENTRATION PER HAND
1/6250
1/8330
1/12,500
1/25,000
Number of Wipes Per Smear
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70

TABLE 1

DATA TAKEN PER ROUND AT BREATHING ZONE OF OPERATOR WHILE TEST FIRING URANIUM XM101 AT LAKE CITY ARSENAL, 5 FEBRUARY 1960

Sample No.	Location	dpm/m3 (above bkgd)*	Fraction of Permissible Tolerance
1	Breathing Zone	0	0
2	" "	0.4 ± 0.01	0.0057
3	" "	0	0
4	" "	0.2 ± 0.02	0.0029
5	" "	0	0
6	" "	0	0
7	" "	0.2 ± 0.02	0.0029
8	" "	0.4 ± 0.01	0.0057
9	" "	0.2 ± 0.02	0.0029
10	" "	0.4 ± 0.01	0.0057

* dpm/m3 disintegration per minute per cubic meter. Background, self-absorption, standard correction, and geometry were all considered in the claculation.

TABLE 2

WIPE TEST PERFORMED ON THE INNER SURFACE OF THE GUN BARREL AFTER FIRING THE URANIUM XM101

No. of Rounds Fired		Total d/m*
1 (one) -	1st wipe	6.7 ± 0.03
	2nd wipe	0
4 (four) -	1st wipe	48.8 ± 0.02
	2nd wipe	9.1 ± 0.04
	3rd wipe	0

* d/m (disintegrations per minute). Background, self-absorption, standard correction, and geometry were all considered in the calculation.